2001

Environmental Factors and Health
The Danish Experience

COWI Consulting Engineers and Planners AS

Danish Environmental Protection Agency
DANCEE, Danish Cooperation for Environment in Eastern Europe

DATA SHEET

Title: Environmental Factors and Health

Subtitle: The Danish Experience

Author: COWI Consulting Engineers and Planners AS

Publisher: Danish Environmental Protection Agency
Strandgade 29, DK-1401 København K
Phone +45 32 66 01 00. Internet: www.mst.dk

Year of publication: 2001

Responsible institution:
Danish Environmental Protection Agency
DANCEE, Danish Cooperation for Environment in Eastern Europe

Notes and other information:
The report is primarily prepared for use in Central and Eastern European countries.

Keywords:
environment, health, legislation, policies, exposure, air, soil, drinking water, bathing water, swimming pools, waste, wastewater, noise, chemicals.

Emneord:
miljø, sundhed, lovgivning, miljøpolitik, eksponering, luft, jord, drikkevand, badevand, svømmebassiner, affald, spildevand, støj, kemikalier.

Abstract:
The report gives a comprehensive overview of the protection of human health in Danish environmental and chemical legislation and administration covered by the Environmental Protection Agency. The report focuses on human exposure from air, soil, drinking water, bathing water, swimming pools, waste, wastewater, noise, and chemical substances. In addition the report gives a brief description of the historical development of environmental policies in Denmark.

Resumé:
Denne rapport giver et overblik over hvordan beskyttelse af folkesundheden er reguleret gennem miljø- og kemikalielovgivning administreret af Miljøstyrelsen. Rapporten fokuserer på eksponering af mennesker fra jord, luft, spildevand, drikkevand, svømmebassiner, affald, støj og kemiske stoffer og forskellige kemiske produkter. Desuden gives en kort beskrivelse af den historiske udvikling inden for miljøpolitikken i Danmark.

Language: English

Number of copies: 500

Number of pages: 308

ISBN 87-7944-518-5

Printed on 100% recycled paper Cyclus.

Table of Contents

Preface

These years we witness an increased focus on environment and health issues. We have always known that the quality of the environment has an impact on human health. In Denmark this became evident already in mid 1800 where the cholera epidemic put focus on, among other things, the design and location of dwellings and sewers in cities. Today we experience several and more severe threats to human health than these "old" contaminants: the use and spread of chemicals, heavy metals and micro-organisms. Environment and health was the primary aim for the Environment for Europe process and it was made substantial at the WHO London Conference on Environment and Health in 1999.

Especially from the Eastern and Central European countries there have been several enquiries on the Danish experience on health based environmental policy. This status report should oblige these enquiries. The report presents a comprehensive overview of the protection of human health in Danish environmental and chemical legislation and administration covered by the Ministry of Environment and Energy.

I hope the report will help create new emphasis on health aspects of environmental legislation. It is also my hope that the report can establish a foundation for further integration of environment and health policies in the Eastern European countries and a basis for greater understanding of the close connection and interaction between regulatory measures concerning environment and health. It is my personal hope that the report can give inspiration to managing similar problems in the Eastern European countries.

The report describes environmental factors in central media, the ways they influence health and the regulation applied to the subjects. The report focuses on exposure from soil, air, wastewater, drinking water, swimming pools, waste, noise, and chemical substances and a variety of different chemical products. In addition the report gives an overview of Danish environmental regulation in relation to health and a brief description of the historical development of environmental policies in Denmark.

The descriptions of factors vary in content, reflecting the different media's complexity and to some extent their weight of influence on human health. Since the report covers the resort of the Danish Environmental Protection Agency, other topics in relation to environmental factors and human health are not included, e.g. exposure via food and the working environment and lifestyle exposures such as tobacco smoke and alcohol.

It is obvious, based on the historical flashback, that most environmental legislation is founded on health considerations. The report shows that efforts to protect both the environment and human health in Denmark are integrated to a large extent.

Svend Auken
Minister for Environment and Energy

The report is available in English and Russian. The reports and annexes can be found on http://www.mst.dk

Summary and Conclusions

The aim of this report is to give a comprehensive presentation of the connections between health issues and the environmental regulation in Denmark. The first 4 chapters give an overall presentation of the interface environment/health and an introduction to Denmark and the environmental regulation. The rest of the report focuses on environmental factors in the air, soil, drinking water, bathing water, swimming pools, chemicals, waste, wastewater and noise. The chapters describe the impact on human health, how the area is regulated and the distribution of the single actor's responsibilities. Furthermore, there is a short evaluation of each area. The evaluation gives an assessment of the level of protection related to the political objectives and identifies the future challenges. These chapters have the same structure but varies in content, reflecting among other things the weight of influence on human health.

Chapter 1 gives some basic information about Denmark, which may enable the reader better to compare the information, presented in this report with the situation in other countries.

Chapter 2 gives definitions of concepts and terms used in the report. The generic model presented describes the life cycle of an environmental factor from emission at the source to human exposure and effect.

The environmental factor is defined as a physical, chemical or biological component in the environment, which may affect human health and well-being. Some examples are micro-organisms, noise, airborne particles, pesticides, metals, and radiation. The environmental factor may be the same and stable in all stages of the system or it may be transformed and finally degraded.

The primary sources in various sectors are described. The source is responsible for generating the environmental factor, which is emitted directly to the environmental media or carried in products and/or waste for later release to the environment. Sectors may be industry, agriculture, waste management etc., and primary sources are the actual emitters of the environmental factors e.g. a factory, a farm, a power plant, etc.

Products and waste are carriers of the environmental factors. Factors may be 'hidden' or lumped together as in 'building materials' or 'chemical products'. Products and waste are conceptually separated from sectors and media.

The environmental media in which the factors subside are air, soil and water. For regulatory purposes the environmental media may however be subdivided. For example, the aquatic media are subdivided into drinking water, surface water and bathing water for which different regulation applies, and important factors may vary.

Humans may be exposed to the environmental factor from the different sectors by contact with products or waste, or through contaminated environmental media. The exposure will depend on the occurrence and magnitude of the factor and the occurrence and behaviour of humans in time and space. Regulation of environmental factors may take place in all compartments. The effects of instruments will vary depending on which level in the system they apply to, e.g. regulation at source will mostly lead to greater downstream effects.

Chapter 3 forms a basis for an understanding of the description in the following chapters on regulations, instruments and actors, as the main characteristics of the environmental regulatory framework in Denmark is presented. Again the focus is health issues, but this chapter gives a broader introduction to the environmental regulation.

The environmental law covers most of the regulation of the environmental factors relating to health, and the environmental authorities are responsible for the imple-mentation hereof. The regulation of environmental factors in relation to health is thus to a big extent a subset of what is normally understood as the environmental regulation in Denmark. However, there are several interfaces with other regulatory areas and authorities, most notable the food and health authorities.

The chapter describes the institutional set-up focusing on the role of the environmental authorities, but also describing the interfaces with other authorities, with EU and international organisations, as well as with other relevant actors.

The principles of Danish environmental law are outlined and the most important environmental acts with relation to health are described. These are The Environmental Protection Act, The Planning Act, The Act on Chemical Substances and Products, The Soil Contamination Act and The Water Supply Act.

Moreover, the chapter includes a presentation of instruments applied for achieving the goal of health protection through environmental legislation, divided into integrative instruments, regulatory instruments, economic instruments and informative/other instruments.

Chapter 4 gives a historical introduction, which highlights major events and trends in the environmental policy and debate and contributes to an understanding of the Danish approach to environmental issues.

The overview is divided into three different historical eras beginning around 1960. In the time before 1960, pollution was not perceived as a general problem to society. However, health problems in the larger cities forced authorities to take actions, the most important being construction of sewage systems and implementation of waste collection.

The eras described in this report are structured according to major changes in the environmental policy.

Initial recognition of health and environmental problems (1960-1972): A growing industrialisation in the Danish society results in a large increase in pollution in comparison with the prior decades, and the Danes become aware of the potential health-depreciating effects of pollution; environmental problems are thus discovered, discussed and acknowledged. The focus rests with the local pollution problems. This era is dominated by a health-oriented concern in relation to environmental problems.

Implementation of comprehensive environmental regulation (1973-1991): In the second era, a Ministry of Environmental Protection is established and the first comprehensive Environmental Protection Act in Denmark came into force. A comprehensive complex of regulation is elaborated and implemented during this period and there is also an increasing use of overall action plans outlining environmental objectives. The international aspects of environmental problems are being recognised. As the European integration speeds up during the 1980s, the European Union becomes a still more important arena for environmental and health policymaking, Denmark being a member since 1973.

Prevention of environmental problems (1992-1998): This era is a consequence of the new Environmental Protection Act of 1992. The focus is on individual responsibility and the period is moreover characterised by a focus on the prevention of environmental and health problems, and an intense interest in the regulation of international environmental problems.

In the recent years, there is increased focus on strategic plans aiming towards a sustainable development and stressing issues such as sector integration and the holistic approach.

Chapters 5-12 describe the environmental factors in relation to the media air, soil, drinking water, bathing water and swimming pools, and in relation to waste, wastewater and noise. The sources, human exposure and potential health impacts of the environmental factors are presented. Danish legislation and regulation together with international protocols and EU-directives are summarised along with the sectoral and institutional framework and instruments used for meeting the national and international requirements for managing health issues connected to the environmental factors.

Chapter 5 describes the environmental factors related to air pollution. Ambient levels of most of the primary air pollutants have been declining over the past decade in Denmark due to among other things improvements in energy production and the requirement of catalytic converters on new cars since 1990. However, the decline of NO2 in urban areas has been rather weak.

For several pollutants it has not been possible to identify lower thresholds for effects e.g. for particulate matter and ozone as well as for carcinogens such as benzene and Benzo(a)pyrene. Based on international studies, the observed levels of fine particles (PM2.5) in Denmark might imply increased premature mortality and illness among sensitive groups: persons with existing respiratory illnesses and persons with heart disease. These groups make up a substantial fraction of the population. The level of these health impacts is only roughly estimated in Denmark, because there has been limited Danish research on this, and monitoring of fine particles has not been regularly performed in Denmark.

The average daily human exposure to dioxins in Denmark is also in recent Danish studies estimated to exceed the WHO guideline for tolerable daily intake, but it is not clear to which extent such an exposure level contribute to effects in the Danish population.

The overall goal in relation to air quality is to achieve a quality without any adverse health effects to the public. Because of the present levels of some air pollutants, a more realistic objective of today, however, is to further reduce the levels of these air pollutants in order to minimise any harmful impact on public health.

The new and planned EU air quality directives, and related vehicle, fuel and industrial directives, will establish consistent limit values for additional pollutants, and vehicle and large-industry requirements in all EU member states. These directives will provide continued reductions in the transboundary pollution that has health impacts in Denmark.

Chapter 6 focuses the environmental factors in soil. A major part of soil contamination originates from former or present activities on the contaminated areas, e.g. industrial and agricultural activities or storage of liquid fuels. Other contamination stems from deposition of airborne pollution. Among the most important pollutants are heavy metals, oil products and additives, polyaromatic hydrocarbons, chlorinated solvents and pesticides. In Denmark, the most significant human exposure routes are considered to be: Ingestion of - or skin contact with - contaminated soil (especially small children), ingestion of drinking water and evaporation of contaminants to indoor air.

The health-based regulation of soil contamination in Denmark has the objective to avoid any harmful impact on public health. In order to fulfil this objective, risk assessment procedures and procedures for the derivation of health based soil quality criteria has been made considering a precautionary approach. Hence, the soil quality criteria are directed towards protection of the most vulnerable group: Small children.

Based on present knowledge, the regulation in broad terms seems to be sufficient to obtain the objective of preventing harmful impacts on public health: There are no recognised cases of harmful impact of soil contamination on public health. A great effort is invested in mapping of contaminated sites and in remediation and/or exposure prevention once contamination is recognised. Mapping and remediation is prioritised, starting with sites with the most sensitive land-use such as residential use, childcare institutions or public playgrounds or sites where groundwater is threatened. Further, liability is the basic principle behind the remediation efforts: The polluter is the primary party to take the measures required combating the impact of soil contamination and to restore the original state of the environment.

Drinking water is the subject media in ***chapter 7***. Environmental factors in drinking water often originate from soil contamination that are washed out and infiltrate into the groundwater. Other sources are extraction-induced contamination e.g. influx of salt or release of nickel from geological layers caused by the lowering of groundwater. Finally, contamination may be introduced in the supply network, especially as microbial growth or as accidental inflow of wastewater.

The objective of the drinking water regulation in Denmark is that the drinking water supply shall be based on unpolluted groundwater - tasteful, clear and free of smell. The consumer shall be able to drink it without worries of contamination. Consequently, the protection of the groundwater resource has a very high priority, and the quality criteria set for groundwater are generally the same (or even lower) as for drinking water, which is basically following the EU directive on drinking water.

Health impacts caused by consumption of drinking water in Denmark are rare and generally the objectives of the regulation are obtained. However, health impacts do occur and primarily as disease caused by microbial contamination in the water supply network. Health impacts from chemical components in drinking water are only observed in a very few cases as nickel allergy (nickel from pyrite rich sediments) or met-hemoglobinemia caused by nitrate.

A key element in the Danish Water Supply Act is the designation of drinking water areas in which main infiltration to the groundwater reservoir takes place. Within such areas detailed mapping and investigations shall identify areas vulnerable to specific contaminants. The areas identified shall be subject to an assessment, comprising a detailed mapping of land use, pollution threats and the geological protection of the groundwater resource. The investigations result in an action plan, which describe the need for action concerning possible restrictions in land use and other human activities. It is within the jurisdiction of the regional and municipal authorities to seek agreements with landowners based on the action plan for regulating agricultural practices, industrial or other activities and possibly purchase of property etc.

An important characteristic of the threat to the drinking water is the delay between the origin of pollution and the occurrence of contaminants in the groundwater, not to say in the drinking water. The delay can be tens of years. Many contaminants are most likely on their way towards the groundwater and cannot be stopped by new regulation. A great number of drinking water abstraction borings has been aborted because of groundwater contamination from either point sources or diffuse sources, and this picture must be expected to continue. Regulation today will in most cases only show results in many years.

Furthermore, all contaminants in groundwater and drinking water are not known because the monitoring programmes only find the substances they are designed for. So other substances not yet being recognised as potential health factors, stay unattended. One of the great challenges of the regulation is therefore to foresee future contamination problems, and in the light of the limited knowledge of many chemicals including their health effects and future occurrence in groundwater, the use of the precautionary principle in the regulation is obvious.

Chapter 8 describes the environmental factors related to bathing water. Environmental factors in bathing water in Denmark are primarily originating in wastewater. The primary impact is by overflow of untreated wastewater during heavy rain, but also by run-off from rural areas and from scattered housing in the countryside not being connected to a wastewater treatment plant. Also incompletely treated wastewater or breakdowns at treatment plants may be sources of environmental factors.

Other sources may be the recreational population using the bathing water, birds and other animals, truly indigenous micro-organisms and to a lesser degree also industrial processes and farming activities. The indigenous micro-organisms of concern are blue-green algae. The algae secrete toxins, but only in rare cases are the concentrations high enough to affect humans. In Denmark there are no fatal cases of human intoxication by algae and no reported epidemics.

There are no recognised cases of negative health impact from contaminated bathing waters in many years, and for the last ten years there has been a further reduction in wastewater impact on the water environment. However, some bathing waters are still influenced by wastewater.

The health objective of the bathing water regulation is to prevent bathing guests from getting ill from bathing in waters appointed as bathing waters. Instruments for obtaining the objective are: The counties and municipalities planning activities, design of wastewater systems, discharge requirements , monitoring of bathing water quality, and occasionally bathing restrictions if the water quality is insufficient .

The microbial quality of bathing waters are monitored, but it is questioned whether the traditional bacterial indicators (faecal coliforms) accurately reflect the quality of the water e.g. the occurrence of more resistant micro-organisms such as viruses and protozoa. Therefore, the Danish monitoring programme is presently under revision also with respect to indicator parameters, monitoring frequency and the reaction time between monitoring result and regulatory action when needed.

Chapter 9 describes environmental factors related to swimming pools, spas and similar recreational water environments.

Environmental factors in the recreational waters include faecally and non-faecally derived micro-organisms originating from the swimmers or contaminated source water, chemicals and by-products related to water treatment, and chemicals that are contributed by the swimmers, e.g. soap residues, cosmetics, suntan oil, sweat and urine.

Human exposure occurs through ingestion of water or inhalation of aerosols and gases like chloroform during swimming and/or through breaks in the protective skin barrier. Acute effects like skin and respiratory irritation resulting from exposure to disinfectants and by-products in the water and in the breathing zone have been described, but the resulting impact on human health is not known. This is also the case with possible long-term effects from exposure to these chemicals. Many of the outbreaks of illness related to swimming pools and other recreational water environments have occurred because disinfection was poorly or not applied. A systematic registration of health related effects from exposure to swimming water and other recreational waters is however not available.

The health objective of the regulation covering recreational waters is to ensure that swimming pools, spas and similar recreational water facilities are operated safely in order to avoid adverse health effects and illness in people using the facilities. Vulnerable groups like children, asthmatics, and sports people who are more frequently exposed are also considered. The goal is to ensure that the swimming pool water has a quality, which will not impair the health of the population and to keep a disinfection level, which prohibits the existence of pathogenic micro-organisms.

The administration of the regulatory requirements is the responsibility of the municipal authorities. The Danish level of protection is considered high, however, the present regulation is under revision to account for the newest knowledge and technical progress.

More knowledge is also required for further improvement of safety, e.g. in relation to the impact of by-products from disinfectants used in the pool water and their toxicological properties. Assessment of possible substitutes to chlorine gas and hypochlorite, which are allowed for disinfection today, is another area of interest.

Chapter 10 focuses on chemicals in products. Both chemical substances which have been put in the products intentionally and chemical substances which appear as contaminants from used raw materials. DEPA's responsibility is primarily related to chemicals, which are marketed in the form of chemical substances, preparations and goods.

Exposure to chemicals largely depends on the use situations. Different patterns are typically seen in relation to occupational exposure to industrial chemicals and exposure of consumers to e.g. household products and chemicals released from toys, clothes and building materials during use.

It is estimated that about 30,000 – 50,000 chemical substances are on the market in the EU. Relatively little is known both about the actual health effects and the effects of the combined impact from different sources on public health related to the use of chemicals. In some areas, e.g. acute toxicity, a certain level of knowledge is available. For acute effects like toxic, harmful, irritant and corrosive effects, it is usually easy to establish a relation between the exposure to a given chemical and the actual effect, because the response follows immediately after the exposure. When it comes to long-term effects like cancer, mutagenicity and reproductive toxicity, it is more difficult to establish firm scientific evidence for effects in humans.

The primary objective of chemical regulation related to health protection is to prevent health hazards and to protect humans from the adverse health effects from exposure to chemicals. A second objective is to promote the use of less health hazardous chemicals through application of cleaner technologies. Key elements in chemical regulation include risk assessment procedures, premarketing approval schemes, classification and labelling of chemical substances and preparations and restrictions in the use of chemicals.

A number of other instruments are in use and a part of DEPA's action plans in order to regulate the use of chemicals and increase the level of protection. These include for example voluntary agreements, green guidelines for purchasing, information and campaigns, taxes and fees and subsidies. As the regulation of chemicals is based on the existing level of knowledge, a major concern in relation to industrial chemicals is the large number of substances for which there is insufficient information with regard to hazardous properties. Substances, which are not fully investigated and not yet on the market, may appear as no cause for concern at first, but later may turn out to be problematic. In addition, the regulation of classification and labelling only considers the hazardous properties of the chemicals. However, possible critical uses of the chemical are only regulated and limited when specific use restriction has been introduced. Another aspect, which needs to be further addressed in the regulations, is the protection of vulnerable groups. In this respect, especially exposure to pregnant women (and thereby exposure to the unborn child) and children should be considered, as these groups may either be more susceptible towards chemical exposure or in some cases more exposed.

One of the major challenges in chemical regulation, are thus the procurement of information about the many substances not sufficiently investigated, and the identification of the problematic substances. In this respect, the DEPA supports the use of computerised QSAR-modelling for predicting inherent properties for substances, which have not been adequately assessed.

A higher level of protection in general will depend on intensified efforts and also generation of more knowledge in a number of areas including prevention of use situations resulting in high exposure, increase in the protection of vulnerable groups, reduction of unintentional spreading of chemicals in the environment. At the same time it will depend on increased documentation from the industry of the safety of chemical substances in use, a reduction in the number of non-assessed chemical substances using QSAR-evaluation, and a prevention of the use and spreading of endocrine disrupters.

Chapter 11 gives a presentation of the environmental factors in waste. Emissions from the general waste stream are described, e.g. from waste production, collection and transport and from waste treatment facilities.

The Danish waste regulation has been very successful in hindering human contact with waste, but still humans may be indirectly exposed to emissions from waste management. The overall health objective of the waste regulation is to avoid any harmful impact on public health, whether it is directly through contact with waste or indirectly through emissions from waste management. From the start of the waste management history more than hundred years ago, protection of public health has been an integrated part of the waste regulation.

The principal strategy is to prioritise waste management in the following order (the waste hierarchy): Waste prevention, reuse, recycling, incineration with energy recovery and landfill disposal.

The regulation of the waste area in Denmark is generally very detailed, and the degree of recycling is high. However, it is still the aim to increase the degree of recycling and to identify and separate the problematic waste fractions in order to limit the emissions of substances that may have a negative impact on human health and the environment. The instruments used are both a detailed regulation and economic instruments such as taxes and waste fees. Among the regulatory instruments, the regulations on specific waste fractions and on hazardous waste should be noted for the objective to separate out the most problematic waste fractions, in order to improve the possibilities for recycling of the waste stream. Also the general principle of waste separation as close to the source as possible is crucial to the possibilities for recycling and reuse. Further the classification of hazardous waste is also a vital health protective measure in the Danish waste management system.

Chapter 12 deals with wastewater and the health related environmental factors connected hereto. The primary health concern of wastewater is exposure through bathing water. Though there has been a large reduction in wastewater impact on the water environment during the last ten years (improved wastewater treatment technology, sharpened discharge requirements, dimensioning of retention basins to minimise rainwater overflow etc.), some bathing waters are still influenced by wastewater. The primary impact is by overflow of untreated wastewater during heavy rain, but also by run-off from rural areas and from scattered settlements in the countryside not being connected to a wastewater treatment plant. However, there are no record of diseases or other cases of negative health impact from contaminated bathing waters in many years.

The overall health objective of the wastewater regulation is to avoid any harmful impact on public health, whether it be directly (caused by outlet to surface water or soil) or indirectly (leaching to groundwater or inflow to drinking water installations, through application on farmlands or through effects on eco-systems etc.).

The existing wastewater regulation in Denmark has generally succeeded in limiting the public exposure to wastewater. Only a few cases of drinking water contamination with wastewater are recorded in recent years in Denmark, and they were caused by flow of wastewater into the water supply network. These cases, however, have caused a number of affected persons.

Both the general effluent limit values and the requested national "coverage" of treatment are stricter in Denmark compared to the present EU-directives. 99% of all wastewater connected to sewers is being treated in a wastewater treatment plant. The Danish Parliament agreed in May 1997 an action plan for improved wastewater treatment for the scattered settlements in the countryside. The actions will include a connection to public wastewater treatment, local sand infiltration plants or small wastewater treatment plants. This action plan will contribute to the improvement of the general water quality in rivers, lakes and coastal waters and thereby also contribute to improvements of the bathing water quality.

Health concern related to chemical contaminants in wastewater focuses on heavy metals and man-made chemical substances, and especially the risk of accumulation in fish in receiving waters or the risk of transference to agricultural crops when sludge is applied as a fertiliser in agriculture. For many years, it has been attempted to recycle the sludge from wastewater treatment plants on farmland as fertiliser. However, difficulties in reaching the required criteria for the sludge and the farmers reluctance to receive sludge as a fertiliser have made it necessary to dispose part of the sludge as landfill or to incinerate the sludge.

Noise is the issue of ***chapter 13***. Noise is the environmental factor that affects most people in Denmark. Many people are complaining about noise, and noise is given great attention in the public. Environmental noise in Denmark is usually so low that it is not likely to cause serious human damage like hearing impairment. However, environmental noise is annoying and may have adverse effects.

Present guidelines and criteria values express a compromise between high quality of life and socio-economic considerations (technical, economical and community aspects), accepting that a minor part of the public (typical the 10% most noise sensitive people) might still feel highly annoyed. Recent environmental noise mappings show that ½-1 million people out of a total population in Denmark of approx. 5 million are suffering from high noise impact. As traffic noise is the main source of annoyance, much effort has been spent on mapping and evaluating possible actions to limit the number of people annoyed by noise from traffic. In 1993, the Danish government decided that the number of housing unit exposed to more than 65 dB(A) from traffic should be decreased from 130,000 to 50,000 before 2010.

Even though it is evident that traffic is the main environmental noise source, present legislation gives no obvious provisions to control or reduce traffic noise from the existing infrastructure. This means that the only way to control and reduce traffic noise will be by good land use and infrastructure planning. The consequence is that the majority of people annoyed by traffic noise are within housing areas in the bigger cities.

For new public infrastructure, noise considerations have to be carried out as part of the Environmental Impact Assessment study. For new enterprises and public infrastructure the noise polluter conducts all costs regarding planning and construction of the necessary noise abatement. Airports have to obtain an environmental approval before getting into operation.

The Danish Planning Act is, among others, dealing with noise considerations as integrated part of new or changed land use and infrastructure planning. The objective of the Act is to ensure that no new noise problems come about.

The European Union will soon present a new "Directive on Assessment and Management of Environmental Noise" dealing with noise mapping, action planning, common indicators and information to the public. It is foreseen that this directive will focus more on noise and the need for measures to control and to reduce the noise impact.

Conclusion

Human health is influenced by a variety of factors of which environmental factors are important contributors together with life style factors, food, factors in the indoor climate and in the working environment.

The actual impact on human health from the individual environmental factors can be difficult to estimate, due to complex exposure situations. Consequently it can be difficult to evaluate the efficiency of the environmental regulation and other instruments in the Danish environmental and health policy in relation to health protection. Different ministries are involved in the protection of human health and there is a need for coordination of the strategies and efforts in this field.

Historically, the primary objective of much of the Danish environmental regulation has been to protect humans from adverse effects in relation to environmental factors as it is the case with waste and waste water regulation. Efforts to protect environment and human health are therefore to a large extent integrated. Furthermore the Danish environmental policy making is generally open and consultative with a range of measures in place to ensure public participation and stakeholder involvement. Environmental information including information about health impact from environmental factors is available through a wide variety of publications and dissemination mechanisms.

In general, Denmark is considered to have a high level of protection in most areas covered by the resort of the Danish Environmental Protection Agency, in particular in relation to soil, water, waste and waste water. The level of protection in the national regulation of environmental factors is in general based on a precautionary approach. Precaution is taken into account e.g. when making risk assessments, in derivation of health based quality criteria using safety factors and in designing the level of protection to the most sensitive target group, e.g. small children.

The precautionary principle is one of the most important new political instruments, which Denmark stresses should be applied to the widest possible extent in fields, which have been regulated by the EU, e.g. chemicals and pesticides. The precautionary principle shall be used by decision-makers where there is a need for action but also a lack of scientific certainty.
There are however, areas where further action is needed and more information about the possible impact of environmental factors is required in order to increase the level of protection and to prioritise and target the effort. Such areas are chemicals, noise and environmental and health factors in relation to air.

More knowledge about the actual impact on health from environmental factors and the effects of regulatory and other measures is required in a number of areas, e.g. fine particles and endocrine disruptors. This is the case both in relation to the resort of the Danish Environmental Protection Agency and the coordination with other authorities involved in health protection.

Environment and health covers a wide range of areas from environmental factors over food and indoor climate to working environment. The challenges towards protecting the human health from a variety of different factors are in general coordinated action. This implies shared knowledge of health impacts and concerns related to environmental and other factors in order to prioritise and target future efforts in a cost-effective way.

The present report also serves the purpose of identifying the various environmental factors with a possible impact on health.

1 Basic information about Denmark

Population. The Kingdom of Denmark is one of the smaller countries in Europe, covering an area of 43,000 km^2, and has a population of 5,3 million. The population is homogenous with few indigenous minorities, and the number of foreigners living in the country is small. The language is Danish.

Government. Denmark is a constitutional monarchy. Under the 1953 Constitutional Act, legislative power is held jointly by the hereditary monarch (who has no formal legal power) and the unicameral Parliament, called Folketinget. The supreme power in Denmark is divided into three independent organs: the legislative, the executive, and the judicial. The legislative power rests with the Folketing; the executive power with the government (the Ministers); and the juridical power rests with the courts of justice. The local government is entrusted to 14 county councils and 275 municipal councils.

Three tiers of decision-making and administration. Danish democracy is organised in three autonomous political and administrative tiers:

- National level: The Folketing (the Danish Parliament), Government and Government departments
- Regional level: The counties; elected county councils and county administrations
- Local level: The municipalities ; elected city councils and city council administrations.

State administration. The state administration - or *the central administration* in Denmark - is similar to other countries divided into a number of ministries each with its special area. Most of these consist of a department and one or more agencies/directorates. In relation to environment and health in particular, the Ministry of Environment and Energy, the Ministry of Health and the Ministry of Food, Agriculture and Fisheries are of importance. The most important duties of the departments are tasks directed at the Parliament (the Folketing), e.g. drafting bills, answering questions from the Folketing, considering applications for appropriations from the Folketing or issuing statutory instruments.

County administration. Denmark is divided into 14 counties each of which is governed by a county council elected for a 4-year periods by direct election using the system of proportional representation. A whole range of administrative functions and services are carried out by the counties namely those which are too comprehensive to be handled by a municipality, for instance the provision of hospitals, post-16 secondary education, vocational training, public transport, and social welfare for the disabled. The counties are responsible for all public hospital services in Denmark, and they administer the National Health Insurance Service. The counties also have a wide range of vital tasks in the field of protection of nature and environment.

Municipal administration. Denmark is divided into 275 municipalities. A local council governs each local authority. The city council budget forms the cornerstone of the council's control of local activities. It is through the budget that the council exercises its right to allocate public funds. Apart from its right to impose taxes, the right to decide on spending is paramount among the council's powers and control measures. The municipalities deal with the tasks close to the citizens, for instance nurseries, primary and secondary schools, libraries, social security, and care of the elderly. They are also responsible for the implementation of a substantial part of the Danish environmental regulation as well as spatial planning.

Economy. The Danish economy has a diversified structure with high-tech industry and advanced business services playing a prominent role as well as agriculture and food production continues to be a significant sector. The educational system is specialised and all over the country there is a well developed network of educational and researches facilities.

Environment and health issues. Political and public interest in the environment and health is strong. The environmental policy in Denmark is characterised by participatory approaches and democratic traditions of initiating dialogues among interests groups in order to achieve consensus in environmental understanding and provide counselling for the governmental authorities.

European Union. Denmark is a Member State of the European Union.

2 Environmental factors with possible health implications

This chapter gives a description of how humans are exposed to environmental factors in Denmark including descriptions of factors, sources, sectors, media etc. An overview is presented and delimitations of the present report are defined.

2.1 Health definition

Health is not an unambiguous concept. It is defined differently by different actors and each specific definition will lead to a certain focus in the health policy, just as a particular definition will facilitate some actions before others, and will in turn place more responsibility on some actors than others.

The World Health Organisation (WHO) defines health broadly: "*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity*" (www.who.dk).

The Danish council for preventive policies which is an official council, appointed by the Danish Ministry of Health, has the task of evaluating initiatives within the field of public health and prevention. The council has advocated a broad definition of health and it states that "*health is a relative concept covering a person's well-being including comfort and ability for self-expression*". Health is thus not merely a medical, but also a psychological, social and cultural concept. Therefore health cannot be defined independently of a person's social and cultural context. (www.folkesundhed.dk).

In 1999, the Danish Government initiated a ten-year prevention programme to improve public health. The programme is aimed at the causes of the relatively negative development in the average life expectancy of the Danes. The programme focuses on life style factors such as tobacco, alcohol, diet, exercise and overweight.

The present report deals with environmental factors influencing human health and well-being. Environmental factors can be physical, chemical or biological, and may include environmental factors in the environment, at home, in the working environment, and in all other places where humans reside also during e.g. transport and leisure time. The report, however, only covers environmental factors, which are under the jurisdiction of the Danish Environmental Protection Agency (DEPA) under the Ministry of Environment and Energy e.g. environmental factors in the environment and from chemical substances and products including cosmetics. The interfaces to other ministries are described in Chapter 3. Although the perception of human health and the factors affecting it remains unchanged, the focus on the responsibilities of DEPA leads to a number of important exclusions from the scope of the present report: Lifestyle factors such as food, tobacco, alcohol, exercise, etc. as well as human effects from accidents and national disaster are not included. Also impacts from occupational exposure and housing conditions are excluded.

2.2 Definitions of system components

2.2.1 Generic model of system

The environmental factors we are seeking to control are those that have en impact on human health and well-being. In the generic system environmental factors are the physical, chemical or biological components e.g. noise, cadmium or the bacteria *Salmonella* capable of accommodating an effect, e.g. emissions from a factory. In the context of ensuring human health and well-being it is important to follow the path of the factor to regulate or prevent it in the most appropriate way.

To identify components of the system between the emission and the potential human effects, a generic model for the 'life cycle' of an environmental factor is presented:

Stage	Component	Remark
1	Emittor	At stage 1, the environmental factor is generated in a sector and emitted from a source.
2	Vehicle	Often the factor is carried in vehicles, such as consumer products or in a waste stream.
3	Compartment	The factor is present somewhere in a compartment such as air or water with specific characteristics.
4	Effect	Finally, at stage 4 the effect of the factor is potentially excerted in the humans.

In fact, the linearity of the 'cradle to grave' process in this model does not provide a full picture, because loops may occur for many chemical substances and products during production, formulation, processing, use, discharge and recovery, and because exposure may occur at all stages.

2.2.2 Development of and exposure to environmental factors

The generic model applied in the field of health and environment is shown in figure 2.1.

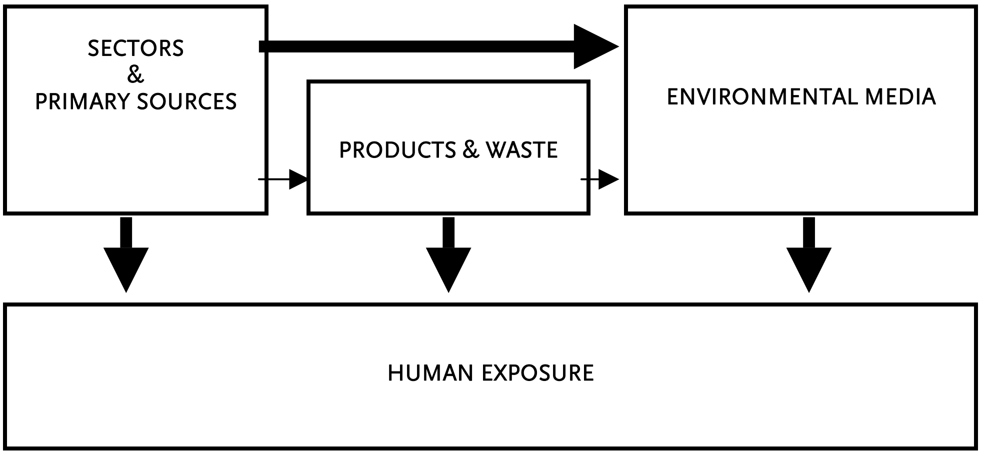


FIGURE 2.1 CONCEPTUAL MODEL FOR THE TRANSPORT AND EXPOSURE OF ENVIRONMENTAL FACTORS. ARROWS INDICATE ROUTES OF ENVIRONMENTAL FACTORS.

The primary sources in various sectors are responsible for generating the environmental factor, which is emitted directly to the environmental media or carried in products and waste for later release to the environment. The environmental factor may be the same and stable in all compartments of the above system or it may be transformed and finally degraded.

Humans may be exposed to the environmental factor in all compartments in the different sectors, by contact with products and waste, or through contaminated environmental media. The exposure will be a function of the occurrence and magnitude of the factor and the occurrence and behaviour of humans in time and space.

Regulation of environmental factors may take place in all boxes and intersect all the route paths (arrows). Obviously, the use of severe or comprehensive instruments at the source will lead to greater downstream effects.

An example of applying approach
Polyaromatic hydrocarbons (PAHs) from traffic may be used as an example: The traffic's emission of PAHs will enter the generic system with the sector as traffic and combustion engines as the primary source. The product/waste step may be omitted here because emissions occur directly to the air. Air is reckoned as the environmental media with urban air as the point of regulatory action. PAHs constitute the environmental factor, which is carried by particles.

Table 2.1 gives examples of regulatory actions aimed at different parts of the system.

Table 2.1 Examples of regulatory actions aiming at different parts of the system.

Point of regulation	Example of regulatory action
Sector/Primary sources	Emission control, ban or substitution of chemicals, working environmental regulations.
Products and waste	Labelling, ban or substitution, waste and wastewater management regulation.
Environmental media	Limit values/quality criteria, measuring programmes.
Human behaviour	Bathing regulations, advice to people living on contaminated land.

2.2.3 Components

Definitions of factors, sources and media etc. are presented below.

Environmental factor
The environmental factor is herein defined as the external physical, chemical or biological component in or of the environment, which may affect human health and well-being. Some examples are micro-organisms, noise, airborne particles, pesticides, metals and radiation.

In cases where the actual factor/stressor can not be identified precisely, or in cases where several factors are operating at the same time, it may be useful to choose an indicator for the environmental factor(s) for regulatory purposes. In connection with air pollution, one could say, as an example, that the limit value for particles (expressed in mass of airborne particles/volume unit in air) may be an indicator for those subfractions of the particles that may be more closely associated with the harmful effects. Similarly, the *E.coli* number is merely an indicator of faecal contamination in bathing water, while the pathogenic effects are connected to other micro-organisms (see section 2.3).

Sectors/Primary sources
This designates the entity responsible for generating the environmental factor. The definition of primary sources and sectors must be understood in a broad sense to include all emitters. Primary sources are the actual emitters of the environmental factors e.g. a factory, a farm, a power plant etc., whereas the sectors may be industry, agriculture, waste management, etc. Some primary sources such as land-fills or other waste disposal sites are filled with used consumer products, which were once new, and at that time derived from another primary source. However, in a process view, emitters are equally good sources regardless of the age of the raw materials.

Products and Waste
Products and waste are carriers of the environmental factors. This compartment has been defined because there are some borderline problems in separating factors from more or less well defined conglomerates of factors, which approach both media and sectors. Factors may be ’hidden’ or lumped together as in ’building materials’ or ’chemical products’. To separate these issues from ’real’ sectors and media these are generically termed vehicles

(transporting many factors) and here named 'Products and Waste'. For the sake of providing an overview it is not crucial whether the environmental factors are 'travelling' in products or in waste, and they may conceptually be grouped together.

Environmental media

The environmental factors subside in the air, soil and water media. For reasons of accuracy and estimation of exposure these may be subdivided into a number of other categories, e.g. groundwater, sediment, organisms living/ growing in the compartment (food items), or subsections of all mentioned. A number of regulations take place here regarding the protection of the environment, and they will in many cases (e.g. air quality) have a human health dimension. For regulatory purposes, the environmental media are often subdivided. For example, the aquatic media into drinking water, surface water or bathing water for which different regulation applies.

Humans

Humans and human populations are, for the sake of completeness, included in the conceptual model, although it is obvious that they are not deliberate 'targets' of the environmental factors. However, it does take both the occurrence of the factor and of the humans to generate an exposure situation which may cause adverse health effects.

Regulatory actions

The regulatory actions will aim at influencing the exposure of humans, i.e. provide a reduction or elimination of the probability of co-occurrence of humans and the factor at the human/environment interface. Regulatory actions may include the use of bans, quality criteria, substitution programmes and a number of other instruments operated at any part of the system (see figure 2.1).

Environmental factors may impact on human health, but in many cases the extent will be difficult to verify. If regulations follow an epidemiological approach this would tend to let the regulatory actions follow the effects, and they would lag behind. A great deal of effort is therefore spent on generating information and regulation based on the predicted risks with the intention of prevention rather than based on the retrospective knowledge. Risk is assessed on e.g. predictions of effects to humans based on experience, test results on various organisms, and knowledge of physical and chemical characteristics of the potential factor.

2.3 Environmental health factors

A complete list of environmental factors is impossible, as numerous chemicals and pathogenic microrganisms subsist in the environment, but not all have health effects and if we allow for some generalisation, a list of groups of factors can be derived:

- Microbiological factors (e.g. pathogenic micro-organisms)
- Physical factors (e.g. noise, UV-radiation, radioactivity)
- Chemical factors (inorganic and organic chemicals)
- Naturally occurring substances
- Man-made or anthropogenic chemical substances.

Table 2.2 Examples of environmental factors , their categories and main risks

Environmental factor	Main categories	Main risk in humans
Microbiological	Pathogenic microorganism	Infections and disease
Physical	Noise Radioactivity UV-radiation	Prominent stress factor Increase in cancer Skin cancer
Chemical	Man-made and naturally occurring substances	Toxic effects from exposure to hazardous substances

2.3.1 Microbiological factors

Pathogenic agents
Water, food and organic material may contain pathogens, typically bacteria, and airborne biological contamination is also well known. The infections caused by e.g. *Campylobacter* and *Salmonella* in food may also occur directly from the environment: *Salmonella* is not uncommon in manure and *Campylobacter* occurs in surface waters. However, most frequently the exposure of humans seems to be from intake of food and drink, and less often related to exposure in the ambient environment (e.g. ingestion of water during bathing or swimming).

Microbiological agents
Generally, micro-organisms constitute an enormous 'realm' with a multitude of bacteria, viruses, fungi, protozoa, planktonic algae and many specific species. A well-known example of a microbiological health factor is the recurring blooms of blue-green algae releasing toxic compounds to the environment.

In recent years, genetically modified organisms (GMOs) have been permitted in some countries for use in the environment, and the risks related to GMOs may be included under this heading. Plasmids and other components of the subcellular level may also be included as environmental factors with a potential for adverse effects in the environment and/or human health, although the knowledge within this area is presently limited.

2.3.2 Physical factors

Noise and radiation differ from the majority of other environmental factors in being wave dispersed and physical rather than chemical or biological.

Noise
Noise must be considered as one of the most significant physical environmental factors. Not because it has the most severe impact, but because noise is perceived by humans far below the doses which will cause serious damage to human health. It may be a nuisance in a broad range of exposure levels and may contribute to adverse health effects like disturbance of rest and sleep, stress, hypertension and ischemic heart disease.

Radiation
These other typical wave dispersed factors cannot be sensed directly by humans and therefore sometimes lead to more severe effects because they may go unnoticed until it is too late. These factors include emissions from radioactive compounds and materials, products emitting radiofrequencies, or ultraviolet radiation (UV). Exposure to UV-light may be indirectly linked to use and release of chemicals (the CFCs) that catalyse the break down of the stratospheric ozone layer, which normally absorbs and protect us from the harmful effects caused by the UV-light emitted by the sun.

Particles
One often regulated issue, which is physical in the sense that it is an object, is the concentration of airborne particles. Especially in urban areas, a great effort is directed into measuring and controlling particles in the air. At present, it is not clear whether it is the particles as physical entities (and the number of these) or the chemical content of the particles (or a combination of both) that is the primary factor for induction of adverse health effects caused by particles.

2.3.3 Chemical factors

It is assumed that some 100,000 chemical substances are marketed on a global level. For Denmark it has been estimated that 20,000 substances, 100,000 chemical products and 200,000 goods/industrial products are on the market.

The vast number of substances can be organised in various ways depending on the necessary level of detail and knowledge. The overall categorisation of substances may be undertaken by dividing the chemicals into natural or man-made (anthropogenic) chemicals, organic or inorganic chemicals, high production volume chemicals or those produced at smaller volumes. However, there are numerous ways to organise the topic. In regulation substances are usually categorised according to their hazardous properties and their field of application. This will be dealt with in detail in chapter 10 on Chemicals.

Naturally occurring substances
The substances and compounds occurring naturally can be both organic and inorganic. Powerful toxicants, such as the inorganics hydrogen sulphide, cyanide or the organic methyl mercury or dioxins are found as a result of natural processes. Plants, animals and fungi may produce biologically active substances, some of which may be acutely toxic or pose other critical effects such as sensitising or carcinogenic effects. Some natural toxicants have a geochemical origin, but some fall in the borderline area to biological agents since they are produced by organisms. Pragmatically, those recognised as substances, and monitored as such, are dealt with under 'Naturally occurring substances' and those identified as the parent micro-organism are dealt with under microbiological factors.

Some naturally occurring substances are biologically active and may affect humans typically through exposure in food or water. Obviously, compounds interfering with actions of hormones and other signal compounds have the potential to give rise to effects; recent examples include the phytoestrogens. This is however, a complicated topic since estrogenic hormones are both naturally occurring substances excreted by mammals and a component of applications in synthetic pharmaceuticals, both of which may occur in waste fractions.

Other natural elements are an integrated part of the environment and always have been. Some have beneficial effects as nutrients, micro-nutrients and co-factors in the human diet or may even be essential, but the very same elements may be toxic in concentrations or doses above a certain level.

The levels of inorganic compounds and elements with potential for adverse effects on human health are enriched in the industrialised society. It is not only the metals, but also a range of compounds e.g. sulphide, cyanide or ammonia. The substances and compounds are sometimes vital for the industrial production as base chemicals e.g. chlorine and various acids and bases.

Man-made chemical substances
The post-industrial era has been called the 'Chemical Age' since the solution offered to many technical problems involves the use of new or existing chemicals or formulations. Most of these compounds are produced for specific purposes, and their use and the products they are part of permeate every aspect of the modern society. A few examples of such compounds are the polymer plastics polyethylene or polyvinyl chloride, detergents such as alcohol ethoxylates or linear alkybenzene sulphonates or even compounds used in pesticides or pharmaceuticals.

The chemicals may be divided into several categories depending on their application pattern, which also influences the potential exposure of humans:

- Industrial bulk chemicals (substances and products)
- Agrochemicals and biocides
- Household and hygiene products
- Human and veterinary pharmaceuticals

The latter is not addressed in the present project, but receives increasing attention due to the focus on endocrine disrupters and the possible occurrence of multi-resistance to antibiotics in pathogenic bacteria.

In general, only a fraction of the anthropogenic substances used and produced in an industrialised society have inherent properties rendering them acutely hazardous for humans. The problem is as much the huge quantities and the many potential exposure situations during the life cycle of a substance from synthesis to release via waste emission or as part of a product. The life cycle may be long for the product and the substance may reside in the human sphere or in nature for long periods of time, if it is not or only slowly degradable. Lack of biodegradation and bioaccumulative properties are therefore unwanted, because such properties leads to a build-up of the substance in food chains that may cause chronic effects after prolonged low-dose exposure. Low level and mixed exposure are especially of concern in relation to chronic effects such as immunotoxic, neurotoxic, carcinogenic and reproductive effects.

The following table provides an overview of the interaction between the major sources of environmental factors and the primary exposure media. An empty cell is not to be taken as evidence of an exposure not being possible in this combination, but rather that it is not a major route of exposure.

Table 2.3 Overview of primary environmental factors in basic environmental media. Chemicals (C), microbiological (M) and physical factors (Noise and chemical induced UV Radiation) are shown.

	AIR		SOIL	WATER		
	Indoor	Outdoor		Ground water and drinking water	Bathing water	Swimming pools
Sources/Producers						
Industry		C, R, N	C	C	C, M	
Agriculture		C	C	C, M	C, M	
Energy production		C	C	C		
Waste disposal and treatment facilities		C,R, M*	C	C,M		
Households	C	C	C			
Transport		C, N	C	C		
Humans					M	M
Products						
Chemical substances and products	C	C	C	C	C	C
Consumed products	C					
Waste products						
Sludge, compost etc.			C, M	C, M	C, M	
Waste water		M*	C, M	C, M	C, M	
Transport from other media						
From air (outdoor)	C		C			
From soil	C			C		
From water						

* Including possible exposure through aerosols.

2.4 Primary sources and producers

The sources and producers comprise the sector or entity responsible for producing the environmental factor, and as mentioned in the definition a sector must be understood in a broad sense. The primary sources and producers of environmental factors are ubiquitous in society. A broad range of classical emitters such as industry, traffic and agriculture can be mentioned, but also a number of disposal facilities can be included, and even humans can be a primary source. A list of the most direct sources includes:

- Industry
- Agriculture and forestry
- Energy production
- Waste disposal and treatment facilities
- Combustion engines (transport)
- Households
- Humans (institutions, hospitals)

2.4.1 Industry

Listed activities and installations
The classical source of pollution is the industrial sector. The most important industries, when talking about pollution, are the so-called listed activities (according to the Environmental Protection Act) and installations which all need an environmental permit. These activities and installations include activities ranging from for example processing and treatment of metals, refineries, chemical and biological production to waste treatment and motor racing tracks. As sources, these sectors are characterised by having an impact on the environment, which needs to be regulated before the activities can take place.

Non-listed activities
The non-listed activities and installations consist of small and medium sized enterprises, most of them producing the same as a listed activity but on a smaller scale. These enterprises do not need a permit but must announce their establishment to the local authorities before starting the activities. The emission of environmental factors from these enterprises is not as high as from the listed activities, but is still of some importance.

Other activities
Other activities include restaurants, offices, dentists, etc. These activities do not seem to be major sources of environmental factors although they generate some waste and may generate noise and odour.

Backyard business
In sectors where demand is high (and in growing economies) entrepreneurs often open a plethora of very small backyard businesses. In terms of sources and producers of environmental health factors, this type of activity may be the source of much emission, which often occurs in or close to residential areas.

2.4.2 Agriculture and forestry

Agriculture
There is a considerable difference in the source characteristics between extensive and intensive farming. Extensive production, such as grass lands and cattle rearing typically does not involve the use of fertilisers, irrigation, pesticides or high energy consumption, whereas intensive agriculture does.

Some crops are more dependent on the use of water, fertilisers and pesticides and may be more labour intensive than others. This may give rise to significant differences in the risk of direct or indirect effects on the population in the area.

Large scale 'industrialised' animal husbandry also leads to large-scale production of waste in the form of manure etc. Many examples of accidental emissions of stored manure polluting surface waters are known. Moreover evaporation of ammonia from manure stored in tanks or applied to farmlands gives a critical nutrient load to vulnerable ecosystems, but may also affect human health and well-being of neighbours.

Recently, attention has been drawn to the potential risk associated with the use of antibiotics as growth promoters in this industry. The concern is that the constant selection pressure applied to the bacteria of the animals may trigger the emergence of multi-resistant forms of pathogenic micro-organisms, which are spread in the environment with manure. Specific antibiotic growth promoters have been banned and/or restricted in Denmark due to this concern.

Forestry

Forestry in natural woods may be comparable to extensive farming, whereas in plantations often both fertilisers/sludge amendment and use of pesticides find its place, especially in production of decorative greenery.

2.4.3 Energy production

Fossil fuels

The energy production is often centralised when using fossil fuels, especially if coal is the source of energy. This may lead to problematic emissions of particles, PAHs, NO_x, SO_2 and heavy metals from smokestacks. It is however, also more feasible to control emissions from fewer sites. The filter dust, the fly ash and slag from coal based energy production require special attendance due to the retained pollutants, especially the heavy metals. For these wastes, special depots are created and various recycling methods are used, e.g. for use in roads, building- and construction materials.

Renewable resources

Energy production based on wind, solar, water and other renewable resources does not infer significant emission of environmental factors affecting human health. Except for hydropower dams, this is typically a decentralised sector although windmill parks are emerging as a feasible solution to one of the nuisances – the noise emitted from the revolving blades of the mills.

Transport

Combustion engines are the source of a number of environmental factors and they are believed to play a major role in causing adverse health effects, i.e. increased mortality and morbidity in the population. Emissions from transportation occur from a great number of small sources and they primarily take place in areas with a large population. Furthermore, the emissions occur approximately at breathing level. Monitoring of traffic emissions therefore has high priority in Denmark and internationally. Also the composition of the fuel and the use of additives may give rise to problems. Previously, the use of organic lead in gasoline was of great concern due to the toxic effects of lead. Today the extended use of MTBE in gasoline is identified as problematic due to a high risk of contamination of the groundwater, which is the primary drinking water resource in Denmark.

2.4.4 Waste disposal and treatment facilities

The very existence of waste disposal and treatment facilities is a matter of human health concern. The aim of waste handling is to minimise human exposure to waste that may be a risk for human health, e.g. in the form of infectious, flammable or otherwise hazardous materials.

Landfills

Landfills are often seen as long-term or even final solutions to the dissipation of problems of environmental factors in the form of waste. Nevertheless, waste disposal by landfilling may lead to direct exposure of humans *via* contaminated or infectious dust or spores, noxious, flammable or explosive gases especially if residential areas are in close proximity or reuse/recycle activities takes place on site. Percolating water from landfills may be severely polluted and may contaminate groundwater or surface waters. Therefore the use of landfilling is minimised as far as possible, and no household-waste is land filled.

The former frequent practise of burning garbage and waste at landfills has been abandoned in Denmark since this may lead to nuisance and health problems in the local environment due to smoke and contamination. The low temperature of such burning may lead to increased emission of polycyclic aromatic hydrocarbons and polychlorinated dioxins and furans, types of environmental contaminants which it is actively sought to reduce.

Waste incineration
Incineration at high temperatures limits the generation of dioxins and furans, but the stack emissions of particles and other contaminants are still a potential source of health problems. In consequence, most waste incineration facilities are equipped with various emission reduction processes; e.g. dust filters and smoke scrubbers. The reduction measures reduce the emission to the environment. It will give rise to new waste products, e.g. filter dust, which can be handled, utilised and/or stored in a secure manner.

Sewage treatment
Sewage treatment also leads to emission especially by the inherent release of sludge and effluent water. Due to the affinity to particles of many anthropogenic substances released from industry and household, the sewage sludge may contain significant amounts of heavy metals and organic micro-pollutants.

The common aeration of the slurry in a sewage treatment plant may lead to emission of volatile compounds, semi-volatile compounds and micro-organisms due to the effect of stripping (transport in aerosols). Again, these impacts are confined to the areas in the vicinity of sewage treatment plants rather than on the population as a whole.

2.4.5 Humans

Humans may also be a direct source of environmental factors in some special cases. These includes situations where humans may infect each other in the same 'media' e.g. in swimming pools and bathing waters through contamination of the water via faeces or from the skin.

2.5 Products and waste

In some instances the primary producer releases the environmental factor directly as e.g. noise or air pollution from traffic, but often the environmental factors are carried to the environment in products or waste coming from the producer. Such products may be ordinary consumer products, materials used for building and construction or e.g. agrochemicals and biocides. In parallel, waste streams also contains environmental factors with a potential for affecting human health. These wastes may include hazardous waste, house-hold waste and a number of more or less well defined wastes from industry, energy production and agriculture.

It is not crucial whether environmental factors are 'travelling' in products or in waste, but common for both is that the factors may be 'hidden' or lumped together as in 'building materials', in 'consumer goods' or 'chemical substances and products'. A non-exhaustive list of typical products and wastes include:

- consumer goods
- fertilisers, agrochemicals and biocides
- materials used for building and construction
- wastewater
- industrial waste and hazardous waste
- non-industrial waste.

2.5.1 Chemical substances and (consumer) products

Shelf chemicals and chemical products

The chemicals sold to professionals and laymen are the source of numerous direct exposures of humans to environmental factors. In Denmark about 8 million tonnes of chemicals are consumed each year in industry, agriculture and households, representing about 100,000 chemical products that include 20,000 chemical substances (DEPA 1996).

Chemical substances and preparations comprise a plethora of items, uses and potential exposures. The chemical substances (i.e. when chemicals are not mixed with one another) that reach the non-professional user are mostly solvents and acids. Typical exposure is during various rinsing and cleaning activities. A relatively frequent accidental incident is oral intake by children and dermal exposures. Chemical preparations are a far more diverse group including for example paints and varnishes, cosmetics, detergents, glues and cleaning agents. The uses and potential exposures obviously span even further than for substances. Some may have profound impact on indoor air quality (paints and varnishes), whereas the use of others may lead to repetitive and prolonged exposure (cosmetics).

A great number of different chemical substances and products are in retail and a considerable effort is directed into labelling the chemical substances with warnings, limiting the anticipated exposures by restricting the use or prescribing specific protective equipment.

The classification and labelling of chemical substances are important instruments in securing a safe and unified way of controlling the use of chemical substances e.g. for what purpose they are used, how they are used etc. The use of classification and labelling is further described in chapter 10.

Substances in consumer goods

Many consumer products are not perceived as the possible source of environmental factors, but chemical substances and products are used in the production of consumer goods. The chemical substances may reside in the consumer product because they serve a specific purpose as a part of the structural material, for stabilisation, for decoration or similar. Examples of chemical substances, which occurred deliberately in consumer products, but are now undesired and sometimes banned are cadmium and lead used for colouring in enamel and glazing, phthalate plastisicers in PVC, and certain non-ionic surface active compounds in various health care products.

It also happens that a residual concentration or contamination from a substance in the produced goods is considered problematic for human health. Most often the concentrations are low, and it is not acute toxicity which is of concern, but rather the long-term effects associated with the substances. Benzene in naphtha used in print colours, residual chlorinated pesticides and dioxin in clothes, nickel in numerous alloyed materials and as contaminants in other, are examples of undesired compounds occurring, not as a result of a deliberate addition during production, but as component of, or contaminant in some material or process in the production line.

Indoor living conditions may be greatly affected by the choice of building materials because of the long-term exposure, little exchange of indoor air, and the huge areas/amount of material potentially emitted from the material surface. Volatile compounds receive special attention since evaporation from walls and floors may lead to high concentration in confined areas with large surfaces. However, the emission of plasticisers from PVC flooring, especially during cleaning with detergents has also received attention.

2.5.2 Fertilisers, agrochemicals and biocides

Fertilisers

Fertilisers and other soil amendment materials may have human health impacts. Applying sewage sludge to agricultural land implies a risk of human contact with sludge, but also spreading of manure may impose severe smell problems and maybe also health effects by inhalation of ammonia. Aerosols containing pathogenic micro-organisms may be formed during spreading of manure and transported over longer distances. Some artificial (phosphorous) fertiliser products have prior been shown to contain cadmium in amounts that Danish authorities considered unacceptable because of possible uptake in plants. Other impacts may be residual concentrations of nitrate in drinking water and food, which are monitored and quality limit values exist.

Pesticides

Pesticides are by virtue biologically active compounds and the possible effects on humans from pesticide residues in drinking water and food entails large scale monitoring programmes to ensure that basic water and food is safe for human health. The use and application of pesticides is a carefully regulated area. Over the past 50 years many pesticides have appeared in the market and disappeared again. Some have been severely restricted or banned due to human health concerns, notably the organomercury and organo-chlorine compounds.

Biocides

Pesticides used elsewhere than in agriculture are called biocides. This may be in aquaculture, ship paints, disinfection, slimicides in cooling systems and a number of other use areas (23 are defined in the EU Biocidal Products Directive, 98/8/EEC). Biocides have a complex use pattern and will pre-sumably be used by a greater percentage of non-professional users compared to pesticides. Biocides may also be spread in residential areas e.g. to combat insects, and may represent a greater risk of exposure for humans.

Biocides occur in many chemical products for preservation purposes, such as in paints and cleansing agents, but biocides are also used in building and construction materials, fabrics and other materials to prevent the biological degradation processes. Obviously, products with a long shelf life or high durability are potentially more likely to be biocide-containing.

2.5.3 Industrial waste

Industrial waste can contain material that may affect human health. However, a system for recognising hazardous waste (which is based on criteria similar to classification of chemical substances and preparations) removes much of the potential exposure and risk. Some minor exposures may still remain, and could possibly contribute to negative impacts on human health, especially in the local environment of the industrial site.

Hazardous waste
Industry produces waste as well as other commercial sectors, but the generation of hazardous waste or products that eventually turn in to hazardous waste are recognised as a great potential danger to human health. The types of hazardous waste and components are separated in many categories, but may for example be corrosive, toxic, irritating or explosive. Often strong acids and bases are among the health problems in industrial waste.

2.5.4 Non-industrial waste

Household waste
Household waste or garbage is generally not considered a significant source of human health environmental factors to the general population (but is a source of health factors in the working environment, notably micro-orgamisms). In Denmark, bio-treatment, or incineration facilities, receives the household wastes. Local burning of such waste may give rise to emissions of a number of unwanted pollutants, notably dioxins and furans.

Wastewater
Public sewage systems handle more than 90% of the wastewater in Denmark, the majority of the rest being led to septic tanks or rarely directly to recipient. Limit values are imposed for the treated effluent and for the produced sludge. Exposure to wastewater or aerosols originating in the treatment process is therefore not common for humans in Denmark. Workers in the sewage treatment facilities may, however, be exposed to wastewater, air or sludge containing environmental factors.

Since sludge is used as a fertiliser in agriculture there is a potential route for exposure to sludge during children's play or other activities in the fields.

Compost
Garden and household compost are in general not considered problematic in terms of environmental factors affecting human health, however, certain problems with infections and breathing of fungi spores are reported from workers in central compost facilities. Effects on the health of the population as such are not envisaged.

Human waste
Household waste from hospitals and other institutions with personal hygiene performed by professionals may contain faeces, urine or otherwise contaminated waste. In cases where such waste is brought to landfills or composted the spreading of infectious material is possible.

2.6 Environmental media and exposure of humans

2.6.1 Environmental media

The environmental factors eventually reaches the environmental media, which comprise the basic air, soil and water compartments. The fate of the factor in the environment is depending on characteristics of the factor itself and of the part of the environmental media where it resides.

The physical-chemical properties of the chemical will govern its distribution in the environment, e.g. volatile compounds will primarily be found in the air media, hydrophilic compounds will mostly be found in water, whereas the strongly hydrophobic compounds will occur in the sludge, sediment or in the biota. The chemical may also be degraded in the environment and the degradation products may be either more or less toxic than the original compound. The degradation of the chemical will depend on characteristics of the chemical itself, but also on the conditions of the environment (occurrence of micro-organisms, nutrient, humidity etc). In the same way the survival of pathogen micro-organisms will depend on the physical, chemical and biological conditions of the environment (temperature, nutrients, oxygen, competition from other micro-organisms etc.)

Soil contamination with mineral oil may be taken as an example. Some of the oil components will be strongly absorbed by soil particles and stay immobile in the soil. Some will be dissolved in percolating water and eventually reach the groundwater. Others will evaporate from the soil to the air and possibly to indoor air in houses build on contaminated land. Degradation of the oil components may take place in all these situations, and the mechanism and speed of degradation will depend on the chemical and physical conditions e.g. the presence of oxygen, water, organic material, the pH of the soil, the mineral content etc.

2.6.2 Exposure of humans

All humans are exposed to environmental factors e.g. through the air we inhale, through the water we drink and through contact with different substances and preparations etc. However we are differently exposed due to differences in our environment and our behaviour. The origin of these differences can be:

- Locality of home and daily activities (city or country-side, special environments)
- Activities we perform in different environments (activities causing special exposure during work, transport, leisure, sports, children's play etc.)
- Choice of food and products such as clothes, cosmetics, jewellery, household chemicals etc
- Housing conditions (building materials, ventilation etc.).

Exposure routes can be direct or indirect. Examples of direct exposure routes are:

- Inhalation of contaminated air
- Inhalation of aerosols containing pathogenic micro-organisms
- Ingestion of contaminated soil or water
- Skin contact with products or contaminated media

whereas indirect exposure may be:

- Ingestion of foodstuff originating from contaminated land
- Wearing contaminated clothes
- Inhalation of vapours from contaminated soil or water.

Vulnerable groups, other risk factors and possible exposure groups are considered in determining a reasonable ’worst case’ direct and indirect exposures for humans, as for example in the European Union Environmental Risk Assessment for Chemicals, the EU TGD (EU 1996).

In addition to the differences in human exposure, differences also exist in the vulnerability of individuals and of special groups. Even for the same individual, the vulnerability may change depending on the person's general health and presence of other stressors. These individual differences may be difficult to handle in a regulatory approach, however, considerations for certain vulnerable groups are central in Danish (and international regulations), e.g. the specific focus on the protection of children and pregnant women.

Children are considered vulnerable due to their physiological growth, development of organs, relatively greater inhalation of air etc., but also due to children activities such as play, putting things in the mouth etc. Thus small children are considered being the target group to protect with respect to contaminated soil, as they may be more vulnerable to chemical exposure and as they are most heavily exposed to soil (direct soil ingestion, dermal soil contact).

Pregnant women are considered another vulnerable group, especially because of the rapid growth and vulnerable periods of the foetus.

2.6.3 Policy in relation to the protection of human health

In recent years focus has increased on the possible influence of environmental factors on public health. During the latest decades an increased presence of allergy amongst the population has been observed, which can hardly be explained by genetic dispositions alone. Because allergic sufferings are developed during infancy, focus has been on exposure to infants and minor children.

The different environmental factors such as indoor climate, contaminated air, foodstuff and different types of chemical exposures are being studied in particular. Furthermore, in Denmark one finds the world largest incidence of testicle cancer, a very high frequency of mutations in the male sex organs, men with a poor sperm quality and for the women, a high frequency of breast cancer. The hormone system and its function have a very important role in those diseases and effects. The influence of environmental factors on the hormonal balance and its development cannot be disregarded in this context. Especially, there is now increased awareness to the fact that in certain periods in embryos and children’s development they are very sensitive to the exposure of chemicals with hormonal disturbing effects. Those chemicals can have fatal consequences for normal development and normal function, especially in relation to the development of the immune system, the central nerve system and the sex organs.

The chemicals that can effect the fertility are seen among animals and organism in the environment and among humans in special working environments.

Therefore, the possibilities of damaging exposures from environmental factors to the public health cannot be disregarded. This is also supported by international investigations, which prove coherence between decreased intelligence and lack of learning ability among children, exposed to environmental factors e.g. lead, mercury, PCB and dioxins during the embryonic stage and/or the years of growth.

In addition, monitoring of environmental factors in the environment has increased at the same time. More attention is paid to the extensive human impact caused by chemicals through soil, air, water, consumables, foodstuffs etc., where it is difficult to predict the health consequences of the totality of the many different exposures.

In the light off the consequences a deterioration of our environment may cause, it is important to use the precautionary principle as a basis in assessments and regulations. In this way, measures can be taken and possible dangers can be remedied before there is a 100 percent scientific proof for often very complicated cause-effect relationships.

When it comes to the Danish environmental regulations, the basic objective is the maintenance of a sustainable environment with special protection of the basic media soil, air and water. Only a very low degree of human exposure of environmental factors originating from human activity is allowed, because other exposure routes with the same environmental factor may often dominate (through foodstuff, chemical products etc.). Often no more than 1-10% of this dose is tolerated through the basic media when the daily acceptable ingestion is assessed.

By the determination of e.g. quality criteria it is the aim to protect all humans, with special consideration of particularly vulnerable and exposed groups in the population (e.g. sick or weakened persons, children and pregnant women). At the same time, safety factors are applied extensively in consideration of the uncertainty in the basic health data (the principles here off are presented in appendix 1).

In Denmark, the protection level is generally regarded as high considered in relation to the regulation areas of the Ministry of Environment and Energy. As it may be seen in the following chapters, it is however at present not possible to maintain a protection level for the public health within all areas, as seen within, e.g., the area of air contamination.

2.6.4 Regulatory approach

Humans are often exposed to the environmental media under circumstances that dictate the use of a particular media subsection, where the exposure may be regulated. Such media are e.g. bathing water and drinking water, indoor air and ambient air, natural soil and agricultural soil.

In some cases, such media may also comprise more than one environmental sub-media, e.g. drinking water may be composed of groundwater and/or surface water.

For obvious reasons it is difficult to regulate the exposure in the ambient environment by regulatory actions on the environment, since the exposure concentrations cannot easily be turned lower. Concerning the environment itself, the regulatory approach is the one of monitoring and setting quality standards, limit values etc. The concentrations in the environment may however be regulated at the source (by emission control, ban of chemicals etc.) or at products and waste (e.g. labelling, substitution of chemicals). It is also possible to regulate the human behaviour. If the counts of thermo-tolerant coliform bacteria in bathing water exceed the quality limit, bathing is not recommended, vulnerable groups (e.g. children) are warned or bathing may even be prohibited. Similar restrictions can be invoked for many other environmental factors.

2.7 References

DEPA (1996): "*Chemicals – Status and Perspectives. Excerpts from a discussion paper from DEPA, English Summary and List of Undesirable Substances*".

homepage: www.who.dk

homepage: www.folkesundhed.dk

EU Coucil Directive 98/8/EC concerning the placing of Biocidal Product on the Market.

EU Commission (1996): *Technical Guidance Documents in support of the Commission directive 93/67/EEC on Risk Assessment for New Notified Substances* and Commission Regulation (EC) 1488/94 on *Risk Assessment for Existing Substances*.

3 The Regulatory Framework

This chapter presents the main characteristics of the regulatory framework in Denmark for handling environmental factors with relation to health within the areas of water, air, soil, chemicals, waste and noise.

Danish environmental law covers most of the regulation of the environmental factors relating to health, and the environmental authorities are responsible for the implementation hereof.

The regulation of environmental factors may be seen as a subset of what is normally understood as environmental regulation in Denmark. This is due as the difficulty is often encountered in distinguishing precisely between "protection of human health" and "protection of the natural environment". Initiatives to combat pollution or actions to steward a healthy environment thus often also result in an increased protection of the health of the population, although this is not always the case. An example would be re-use of rainwater or wastewater sludge, which from an environmental perspective may be encouraged, but from a human health perspective could cause concern.

Even though regulation of environmental factors with relation to health is part of the environmental regulation, there are several interfaces with other regulatory authorities, most notably the food and health authorities. These are briefly described in this chapter as well.
Moreover, the chapter includes a presentation of instruments applied, along with a presentation of the Danish environmental law and a discussion of implementation features.

3.1 The institutional set-up

At all administrative levels - national, regional and local - the environmental decision-makers and administrators are the prime responsible actors with other authorities playing a complementary role.

The environmental authorities administer the environmental law and monitor the state of the environment while the health authorities monitor the state of the public health and provide environmental-medical assistance and advice at local and regional level in specific environmental cases. The role of the Ministry of Food, Agriculture and Fisheries is to ensure that food is safe and uncontaminated. Overall, it can be stated that the Ministry of Environment and Energy and the Ministry of Food, Agriculture and Fisheries are the responsible authorities for the regulation of environmental factors in relation to the environment (the media), industry, chemical products and food.

The environmental authorities apply a broad perspective to environmental protection, including health concern: to secure that the population is not exposed to harmful substances.

The approach of the health authorities is to follow the health status of the population and to evaluate the overall effects in the population e.g. from exposure to (all) environmental factors, including other chemical factors in relation to life style e.g. tobacco, alcohol, use of drugs, etc. Thus the task of the health authorities is first of all to follow the health status and to inform other responsible authorities and the public in specific cases where a problem is identified. Important actors at national level include, but are not limited to, the following:

- The Parliament and the parliamentary committee for Environment & Planning
- The Ministry of Environment and Energy, in particular the Danish Environmental Protection Agency
- The Ministry of Food, Agriculture and Fisheries, in particular the Danish Veterinary and Food Administration.
- The Ministry of Health
- A number of public and private stakeholders

Relevant actors at regional level include:

- County councils and the county council committees for environment & technical affairs
- The county departments for environment & technical affairs
- Medical officers of health; subordinated the Ministry of Health, but working at county and municipal level.

At the local level, environmental factors in relation to health are in particular dealt with by:

- City councils and city council committees for environment & technical affairs
- Municipal departments for environment & technical affairs.

In the sections below, a more detailed description of the actors involved in regulation of environmental factors is given.

3.1.1 National level

Policy-making at national level takes place in the Danish parliament, "Folketinget". The parliament lays down the rules e.g. for environmental factors in relation to health, it appropriates money to fulfil the purposes of the legislation, and it oversees the administrative implementation of the legislation based on an interest in the realisation of the goals.

Even if the decisions are made formally in the Parliament, the preparation for decisions is carried out prepared in the standing committees. The work of the committees is primarily linked to the drafting of policy initiatives, reading of Bills and proposals for parliamentary resolution.

Environmental factors relating to health are the concern of the Environment and Planning Committee as it covers e.g. environmental protection, nature protection, spatial planning and gene technology. At any time the Committee can pose questions to the minister on aspects relating to the environment. Moreover, health aspects in relation to environmental factors are from time to time dealt with in the Health Committee and the Committee for Food, Agriculture and Fisheries.

The Ministry of Environment and Energy is in charge of environmental protection, which includes human health aspects deriving from environmental pollution. In co-operation with, among others, counties and municipalities, the Ministry is responsible for compliance with the law and for the implementation of most of the environmental policies. The ministry's agencies employ approximately 1.100 employees of which only a small part work with environment and health related questions. The ministry also contributes to the policy-making process via initial preparation of action plans just as the ministry issues guidelines.

The ministry manages three independent research institutions of which the National Environmental Research Institute in particular generates knowledge of relevance for handling environmental factors in relation to health.
The basic expert and administrative work of the Ministry is carried out by its three agencies: the Danish Environmental Protection Agency (DEPA), the National Forest and Nature Agency and the Danish Energy Agency, of which the former is responsible for the regulation of environmental factors covered by this report. Ministerial briefs, etc. on matters that lie within the areas of responsibility of the agencies are provided directly by these agencies.

The Danish Environmental Protection Agency (DEPA) administers environmental legislation and implements environmental policy measures with the assistance of municipal and county authorities. The agency with its regulatory approach typically deals with the environmental factors one by one and only seldom does it focus on the cumulative effect of environmental factors in relation to public health.

The table below provides an overview of the role of DEPA for each of the environmental media. For a more accurate description, we refer to the chapters covering these environmental media.

Table 3.1 Overview of the responsibility of the Danish Environmental Protection Agency in relation to the environmental media

Media	Role & responsibility of DEPA
Drinking water	DEPA is responsible for the preparation of draft acts, statutory orders and guidelines on water resource planning and provides guidance for the work of the regional and local authorities and supports research and development.
Bathing water and swimming pools	DEPA is responsible for the preparation of draft acts and statutory orders and provides guidance for the work of the regional and local authorities. DEPA is responsible for sending the results of the bathing water quality monitoring to the European Commission.
Wastewater	DEPA is responsible for the preparation of draft acts, statutory orders and guidelines on wastewater, and provides guidance for the work of the regional and local authorities and supports research and development.
Air	DEPA lays down policies and objectives concerning combating air pollution and prepares draft acts, statutory orders and guidelines to reduce air pollution. Finally, DEPA provides guidance for the work of the regional and local authorities and supports research and development.
Soil	DEPA prepares and administers the legislation and guidelines on contaminated soil, waste sites and landfills and supervises clean-ups and purification operations for chemically contaminated soil. DEPA provides guidance for the work of the regional and local authorities and supports research and development. DEPA is responsible for the continuous elaboration and updating of

Media	Role & responsibility of DEPA
	the health based soil and drinking water quality criteria. The work is co-ordinated and supervised in a forum including representatives from the Ministry of Food, Agriculture and Fisheries, the Ministry of Health, and the Councils.
Chemicals	The administration of the Chemical Substances and Products Act is centralised in DEPA and very little authority in this area is delegated to the local authorities. The reason for this is that the area demand high specialisation. DEPA administers the act and is responsible for negotiations at the European and international level.
Waste	DEPA is responsible for the preparation of draft acts, statutory orders and guidelines. DEPA prepares statutory orders on waste and specific categories of waste. This work includes definition of criteria for hazardous waste, including waste with an impact on human health. Finally, DEPA provides guidance for the work of the regional and local authorities.
Noise	DEPA prepares draft acts, statutory orders and guidelines on noise from trade and industry and from traffic. DEPA provides guidance for the work of the regional and local authorities and supports research and development. DEPA is responsible for the continuous elaboration and updating of the national guidelines.

The Ministry of Food, Agriculture and Fisheries is responsible to ensure that the produced and distributed foodstuffs are safe and environmentally sound.

The Danish Veterinary and Food Administration that is part of the Ministry of Food, Agriculture and Fisheries undertakes, as consultants for DEPA, several tasks concerning toxicological assessment and risk assessment, used in the regulatory work of DEPA. The Veterinary and Food Administration has since 1983 followed the concentration of a number of environmental pollutants in foods, e.g. a number of chlorinated persistent organic pollutants (e.g. PCB, DDT, dieldrin, lindane, etc.) and metals such as arsenic, cadmium, lead, nickel and mercury.

The Danish Veterinary and Food Administration is responsible for limit values in relation to the maximum use of food additives (the Positive List), and for the presence of pesticide residues and certain contaminants in foods. In the EU, the limits for food additives and some specific contaminants are subject to full harmonisation. At the practical level 11, the Regional Veterinary and Food Control Authorities carry out food and veterinary inspection and provide information and guidance concerning legislation etc. within the veterinary and food area.

The Ministry of Health, being the principal health authority in Denmark, is responsible for the general development in the health sector including health promotion, as well as it sets up guidelines for the running of the health care services. As almost all health care services are provided at the regional and municipal administrative levels, the task of the Ministry of Health is first and foremost to initiate, co-ordinate and advice.

The Ministry of Health approaches health problems deriving from environmental factors from a public health perspective, meaning that the focal point is human health and all those factors impacting hereupon. The Ministry of Health is not responsible for the regulation of environmental factors described above, but can advise and assist the responsible authorities in specific cases.

The tasks performed in relation to environmental factors include maintaining contact to other ministries (e.g. the Ministry of Environment), the medical officers of health at the regional level, and relevant research organisations. The National Board of Health thus participates in steering committees and working groups with DEPA on environment and health issues.

The role of the ministry in relation to environmental factors also includes co-ordination of policy-initiatives and policy objectives with e.g. the Ministry of Environment and Energy (see also section 3.2).

The Medical Officers of Public Health co-operate closely with county and municipal environmental authorities. There is one medical office institution in each county. The medical officers are in regular contact with the National Board of Health and DEPA in order to ensure co-ordination and updating of management of environmental and health problems.

The role of the medical officers of health consists in general of monitoring the state of health in each county, including health aspects deriving from environmental factors. The Medical officers of health are independent of county and municipal authorities as well as being independent of economic interests. As such, the medical officers of health maintain an important task securing that municipal decisions are in accordance with laws, statuary orders and guidelines from the central authorities and providing citizens with advice and help.

The medical offices have a legally founded advisory role but no formal decision-making power. The main influence rests with "the good argument" and the institution of medical officers do in fact enjoy a reputation of high quality advising. This may explain why the municipal and regional authorities largely follow the recommendations given by the medical officers.

The medical officers are granted, in the environmental protection law, a formal right of complaint in relation to decisions made on the so-called chapter 5 enterprises - those enterprises requiring an environmental permit. This source of influence is, however, administered somehow differently, as the medical officers prior to the permit being issued are often involved in the permit granting process. They assess the drafts from an environmental health perspective.

The National Working Environment Authority (NWEA) is the competent authority in relation to working environmental matters and is subordinated the Ministry of Labour. NWEA carries out inspections of the working environment, e.g. at construction sites and checks among others compliance with rules issued by DEPA on classification, labelling and sale of chemicals. NWEA shares the National Product Register with DEPA. NWEA also undertakes some tasks concerning risk assessment of chemicals.

Research into environmental factors with relation to health is undertaken by public research institutions managed by the ministries of environment, health and food. The most important institutions are listed below:

- *The National Environmental Research Institute* is an independent research institute under the Ministry of Environment and Energy conducting research in the state of the environment in water, soil and air and the trends in various types of habitats and the populations of wild fauna and flora. Based on this, the Institute provides scientific advice for the Ministry of Environment and Energy, the counties and the municipalities as well as private companies.

- *The Geological Survey of Denmark and Greenland* (GEUS) is a research and advisory institution within the Danish Ministry of Environment and Energy. GEUS assists the Ministry in its administration of the utilisation of water resources and the subsurface, including the supervision of exploration for and exploitation of oil, natural gas, geothermal energy, etc.

- *The Institute of Food Safety and Toxicology* is subordinated the Ministry of Food, Agriculture and Fisheries. It advises on safety in the context of food additives, nutrients, pollution, pesticide residues, antibiotic resistance, etc. The Institute also advises the National Forest and Nature Agency/DEPA on health risks associated with various chemical substances and products, genetically engineered organisms and their products, and the general environmental pollution of soil, water and air.

- *The National Institute of Public Health* is an independent institute under the Ministry of Health doing health research, diseases and mortality of the population, and research in health promotion, prevention and treatment. This knowledge may function as input to e.g. target setting in relation to environmental factors.

- *The Research Centre for Environmental Health* is established by the Ministry of Health in order to promote research in effects in humans due to the exposure from biological, chemical, physical, and psycho-social factors, mediated through air, soil, water, foods, the indoor environment, and the working environment.

- *The National Institute of Occupational Health* is an independent government research institute affiliated to the Ministry of Labour. It refers directly to the Ministry of Labour. The profile of the institute is laid down in the Working Environment Act and the rules for the National Institute of Occupational Health.

- *The Danish Zoonosis Centre* is an epidemiological research unit established in 1993 by the Ministry of Food, Agriculture and Fisheries in order to collate information regarding zoonotic diseases, so they can be efficiently prevented and controlled.

- *The Danish Veterinary Laboratory*, which is subordinated the Ministry of Food, Agriculture and Fisheries, is a part of the overall Danish veterinary preparedness. It aims at securing the production of healthy (safe) livestock products to the benefit of producers and consumers.

A number of public and private stakeholders take part in the Danish environmental policy.

Denmark has incorporated the Aarhus Convention into the Danish legislation. The convention has three central perspectives regarding citizens' rights in the environmental area: 1) Access to information, 2) access to participation in the decision making process and 3) access to complain and have decisions tried by the court. The main principle is that only by access to knowledge, citizens have a real possibility to participate in the democratic process. Only when the citizens know why decisions are made – or not made – it is possible for them to participate in dialogue and to involve themselves in finding solutions. Denmark has a long tradition of involving the citizens and organisations in the decision making process in the environmental area.

There is a large number of organisations and co-operations in Denmark. These organisations can roughly be grouped in three: Organisations representing labour market partners, industry, trade and the energy sector; organisations representing environmentalists, ecologists, consumers etc.; and organisations representing public authorities. Some organisations are small and might not have strong political power. Other organisations are very involved in the political debate and have a strong influence on the political agenda.

These organisations participate in the public debate and put political pressure on authorities, parliament, government etc. with the aim of promoting their interests. Environmental funds, etc. established by the Ministry of Energy and Environment are open for both private and public stakeholders, including organisations. Considerable economic and professional support has been transferred to organisations by the ministry during the years.

The Ministry of Environment and Energy involves the organisations in several ways. A number of environmental acts orders the Minister for the Environment and Energy to negotiate with the most relevant national business and environment organisations, organisations of local authorities, and with other state authorities involved before laying down rules under the Act. See for example Article 11 of the Environmental Protection Act. This includes negotiation of EU-directives as these rules are going to be a part of Danish law, when entering into force. Further, the Ministry of Environment and Energy has a tradition of a very close contact to the organisations etc.

In addition, the Minister has established a minor number of independent advisory boards. The boards consist of experts within their field, and their task is to advise the Minister on environmental matters and to contribute to the public debate. In the following, some of the major organisations are listed:

Organisations representing labour market partners, industry, trade, agriculture and the energy sector:

- The labour market partners are well organised in Denmark, where more than 80 per cent of the employees are members of a trade union. The trade unions are grouped in national federations, which are affiliated to a small number of central organisations. The employer organisations have a similar structure. The biggest central employee organisations are the Danish Confederation of Trade Unions (LO), the Salaried Employees' and Civil Servants' Confederation (FTF) and the Central Organisation of

Academic Staff (AC). The biggest central organisation on the employer side is the Danish Employers' Confederation (DA).
The Confederation of Danish Industries (DI) is by far the largest organisation under the Danish Employers' Confederation. The collective agreements of the DI cover half of the employees in the fields covered by the DA. As a response, the employees have formed cartels of which individual trade unions are members. The biggest cartel in the private sector is the CO-Industry.

- *The Association of Danish Power Plants*[1] represents 150 members and their interests concerning economy, energy and environment in a dialogue with the Parliament, the Government, authorities and private enterprises. The Danish power plants play an important role in the Danish energy and environmental policy with relation to air pollution. During the years, the power plants have been subject to several state initiatives concerning the use of biomass fuel, the establishment of wind mill parks, the change-over from coal and oil to gas and biomass fuel, taxes on SO_2 and CO_2 emissions, etc.

- *The Danish Agricultural Council* is the joint body representing the main organisations of the farming industry in its dealings with the Government, the Parliament, other industrial bodies and sections of the Danish community, as well as internationally. This means that The Agricultural Council is the central forum for the main aspects of Denmark's national and international agricultural policies. The Council also carries out a number of service functions in such fields as export promotion, information, education, conferences, property administration and the provision of capital. Added to this are secretarial services in many different areas.

Organisations representing environmentalists, ecologists, consumers, etc.

- *The Danish Society for Conservation of Nature*[2], DN, is a private environmental NGO-organisation of approximately 200,000 Danes. DN operates through 220 local committees and through 14 consultative councils. The national daily business is headed by the National Steering Committee, called the Board or "Forretningsudvalget". In a number of networks and other working groups academics and grass roots work together to improve public awareness on e. g. nature conservation, environmental management, Agenda 21 and waste management. DN takes interest in a large scale of environmental and health issues and participates actively in the public debate.

- *The Ecological Council*[3] is an NGO founded in 1991. Its main objective is to promote sustainable patterns of development, where environmental concerns, social justice and human well-being are main focal points. The Ecological Council is different from other Danish NGOs as it is an academic organisation dealing with environmental policy on a scientific basis, but at the same time trying to inform and have a dialogue with both politicians and the general public.

[1] www.home7.inet.tele.dk

[2] www.dn.dk

[3] www.ecocouncil.dk

- *The Consumers Council*[4] was founded in 1947. The Council is an independent body representing the consumers and their interests vis-à-vis the Government, the Parliament, public authorities and trade and industry. The Consumers Council deals with a large number of questions, including questions in relation to food, environment and health. The council is represented in more than 200 committees and work groups dealing with questions of relevance for the consumers.

Apart from the mentioned organisations there is a tradition for collaboration with green NGO's, e.g. Greenpeace and The Danish Outdoor Council.

Organisations representing local authorities:

- The *municipalities* have organised themselves in a private organisation called the National Association of Local Authorities in Denmark. The municipalities have placed the negotiating power in this organisation, which politically and financially commit the municipalities through negotiations with for example the Ministry of Environment and Energy. A similar system exists for the *counties* through their organisation the Association of County Councils. These two organisations have significant bargaining power and influence on the decentralised environmental policy decisions in Denmark.

3.1.2 County level

Policy making at county level takes place within the county councils. Moreover, each county council has a number of committees. One of these would normally be the committee for technical and environmental matters whose responsibility is environmental administration within the county. The committee determines the outcome of most cases concerning environmental matters, cases only exceptionally being placed on the agenda of the county council itself.

Most county councils also have a committee responsible for health/hospitals but it is seldom involved in the handling of environmental factors with relation to health. The medical officers, on the other hand, will often be in close dialogue with the environmental authorities. Therefore, exchange of viewpoints and information often takes places at the level of civil servants.

Environmental administration at county level is comprehensive, as environmental administration in Denmark to a high degree is decentralised to the elected county and municipal councils leaving substantial discretionary powers in law to the counties and the municipalities. Under the main Environmental Protection Act, for instance, the main responsibility for implementation thus rests with the county councils and municipal councils. Each county therefore has an environmental department, with substantial human capacity.

One of the main responsibilities is the approval and inspection of industrial plants considered as the larger polluters (approximately 7000). The approval procedure for polluting industries covers air, water, waste, etc. Over and beyond the role played in relation to approval, the counties perform several other tasks of importance for the environmental media. An overview is given in the table below.

---

[4] www.fbr.dk

TABLE 3.2 OVERVIEW OF THE RESPONSIBILITY OF THE COUNTIES IN RELATION TO THE ENVIRONMENTAL MEDIA

Media	Role & responsibilities of the 14 counties and the municipalities of Frederiksberg and Copenhagen.
Drinking water	According to the Water Supply Act , the counties are responsible for ensuring a sufficient water resource of a satisfactory quality and implementing the measures necessary to meet these requirements. The counties are responsible for handling applications for water abstraction exceeding 3,000 m^3/year. The counties shall in understanding with the municipalities undertake water resource assessment and planning, mapping, vulnerability assessment and action planning for protection of the water resource.
Bathing water	The county and municipal authorities are responsible for the administration of the legislation on bathing water and are obliged to ensure that the quality objectives of the legislation can be met and also maintained.
Waste water	The counties are the main responsible for regulating discharges to the recipients. However, the municipalities are responsible for discharges from industry and trade subject to environmental permit by the municipalities. The counties also prepare the regional plans for waste water treatment.
Air	The counties are responsible for the monitoring and assessment of the ambient air quality. Counties and municipalities, in order of the environmental protection act, lay down requirements for emissions of air polluting substances from industry and agriculture[5] and supervise compliance with law.
Soil	The counties are responsible for the provision of information on contaminated sites, mapping, and for the remediation of orphan, contaminated sites. Furthermore, the counties give permissions for voluntary clean-ups and changes in landuse of contaminated sites. The counties are also responsible for the supervision of (potential) contamination occurring at some of the activities listed in the Environmental Protection Act and may give enforcement notices to polluters.
Chemicals	None.
Waste	The county councils shall inform the Municipality as to whether the municipal waste management plan is in accordance with the strategy and assumptions in the county's Regional Plan. According to the Planning Act, the county is responsible for making provisions for the location of polluting enterprises, including new landfill sites, incineration plants and other waste treatment facilities.
Noise	Environmental permits of airports, industrial activities, shooting ranges and motor racing tracks are handled by the municipalities or counties. Requirements on noise are laid down under the permits.

3.1.3 Municipal level

Policy making in the municipalities takes places within the city (or town) councils and the city council committees. The municipal committee structures deviate significantly between municipalities. Thus one can find many different committees with responsibility for environmental administration. The most common, however, is that it lies with a committee for technical and environmental matters. As in the case of the counties, the committee has the responsibility for the daily administration with cases only exceptionally being brought before the city council itself.

[5] EPA art. 33 and 35 and 42.

Environmental administration at municipal level is comprehensive. The Danish environmental administrative model emphasises, as already mentioned, public control and responsibility at local level. This is in particular true within the fields of waste management and wastewater treatment where the municipalities bear the sole responsibility. Often, municipalities will co-operate in carrying out these duties, e.g. there are a number of inter-municipal waste disposal companies. Municipalities are also responsible e.g. for the inspection of smaller polluters including 6,000 industrial companies and 59,000 farms and issues relating to discharges and the sewerage system.

The table below provides an overview of responsibilities in relation to the environmental media covered by this report.

Table 3.3 Overview of the responsibility of the municipalities in relation to the seven environmental media.

Media	Role & responsibilities of the 275 municipalities
Drinking water	The municipal authorities are responsible for the water supply and monitoring of the quality in the municipality including handling of applications for water extraction from private and public applicants (less the 3,000 m^3/year), supervision of public water works and planning and supervision of the supply network. The municipal council may propose and apply for the county councils approval of their own action plan for water resource protection should it find that the overall water resource planning conflicts with the best interests of the municipal and/or the municipal water supply.
Bathing water and swimming pools	The municipal authorities are responsible for the administration of the statutory orders e.g. supervising the quality of bathing water and pool waters, that the systems and procedures run as they should, monthly sampling and analysis, forwarding the analytical results to the county authorities and the medical officer on health etc.
Waste water	The municipal authorities are responsible for treatment of wastewater led to the public sewer, for control of industries and discharges, and for preparation of discharge permits. The municipalities furthermore prepare the wastewater master plan.
Air	Counties and municipalities, in order of the environmental protection act, lay down requirements for emissions of air polluting substances from industry and agriculture and supervise compliance with law.
Soil	The municipalities are responsible for the supervision of (potential) contamination occurring at the majority of activities listed in the Environmental Protection Act and may give enforcement notices to polluters. The municipalities give instructions on disposal of contaminated soil.
Chemicals	None.
Waste	The municipalities are responsible for waste management, and are obliged to ensure that all waste produced within the municipality is collected and treated appropriately. The Environmental Protection Act and the Statutory Order on Waste stipulate the responsibilities of the municipality, which include: preparation of waste plans; preparation of by-laws; ensuring that the waste hierarchy is observed and ensuring that waste is handled in an environmentally safe manner, either via assignment or collection arrangements; enforcing the national and municipal waste management legislation.
Noise	The major municipalities and cities are doing noise mappings for road traffic noise as part of their Environmental Action Plans.

3.2 Mechanisms of co-ordination

In the previous section it was shown that regulation of environmental factors in relation to health takes place first and foremost within the "normal" environmental regulatory set-up. Still, there is an obvious need for co-ordination between the environmental authorities and other authorities involved in handling environmental factors in relation to health. This section gives examples of mechanisms by which interaction and co-ordination takes place. It will not give a complete picture of interaction and the problems associated herewith, between the different bureaucracies, but will nevertheless provide an insight into the aspects of this co-ordination process.

3.2.1 Co-ordination with food authorities

There is a historical tradition for co-operation between the Danish Environmental Protection Agency and the Danish Veterinary and Food Administration; the later being used as a consultant to DEPA in matters relating to health.

At the Institute of Food Safety and Toxicology, about 11 man-years of work capacity is reserved for assistance to DEPA in relation to research and toxicological and health evaluation of chemicals. Thus, there is a close co-operation in areas relating to classification of chemical substances, risk assessments, elaboration of quality criteria for soil, air and water. Also the expertise of the institute is used on an ad-hoc basis, in situations demanding toxicological knowledge. Examples hereof include crops grown in soil in domestic gardens, re-use of sludge, drinking water quality, etc.

Some examples of recent projects conducted in common by DEPA and the Danish Veterinary and Food Administration are the following:

- Review of existing knowledge on the special risk faced by children and pregnant women in connection with exposure to chemical substances
- Generation of improved scientific basis for assessing combination effects, i.e. effects that occur upon exposure to several chemical substances simultaneously
- Upgraded efforts and research concerning chemical substances' hormone-like effects and negative effects on reproduction.

A formalised co-operation takes place in relation to DEPAs procedure for approval of pesticides. The Danish Veterinary and Food Administration undertakes health assessments in relation to acceptable daily intake (ADI) and maximum chemicals residue limits (MRL).

3.2.2 Co-ordination with health authorities

The co-ordination with health authorities takes places partly on an everyday basis with contacts and information being shared between civil servants within different agencies when necessary.

Cross-ministerial exchange of viewpoints and information is also done in a variety of working groups and committees. The Danish Environmental Protection Agency will thus as the main rule invite the National Board of Health to take part in projects that deal with health aspects. The National Board of Health is thus constantly represented in two steering committees covering the elaboration of health based quality criteria for air, soil and drinking water.

The Ministry of Environment and Energy together with the Ministry of Health and the Ministry of Food, Agriculture and Fisheries elaborated a joint ministerial report concerning protection of children and pregnant women against hazardous substances. The report covered the outcome of a common conference having the same title and described the activities in the field of protection of children and pregnant women against hazardous substances.

Another recent example of co-ordination is the participation of the Danish Environmental Protection Agency in a committee affiliated to an investigation concerning contamination of mother's milk.

In 1998, a common task group for the assessment of the health implications of the EU limit values for air pollutants were established. The group embraces the National Board of Health and the Ministry of Environment and Energy as well as other experts take place in the group.

3.3 Danish environmental law

There is no specific Danish definition on the terminology "Danish environmental law". However, environmental law is defined as those regulations covering trade and industry's and person's effects on the outside environment[6], meaning primarily regulation on environmental protection, protection of nature and planning of the use of land.

As already mentioned, health is an integrated part of the Danish environmental policy and regulation. Areas of health with relation to environment rest with the Ministry of the Environment and Energy. Hence, in the following reference will only be made to environmental law (including health).

Environmental law in Denmark consists of a very comprehensive system of rules, comprising different sorts of regulations and various competent authorities. There is a widespread use of *framework legislation* in Danish environmental law. The framework legislation establishes the general aims and objectives, the allocation of competencies among authorities and the relevant principles and procedures. More detailed regulation is laid down in orders and guidelines prepared by order of the act.

Statutory orders are used as "sector-based norms" and in relation to the procedure - e.g. in making decisions on licences. Such orders are binding administrative rules.

Guidelines contain general interpretation of acts and statutory orders and also offer some recommendations or suggestions for the application of discretionary provisions laid down in acts, statutory orders and plans. Guidelines are binding upon the administration to the extent they reflect administrative practice.

In addition, the activities of environmental authorities are to a considerable extent governed by *administrative principles*, which stem largely from administrative policy and from judicial review of administrative decisions.

---

[6] Cf. Revsbech, p. 1. This interpretation means that regulations on e.g. working environment and food are not covered by the terminology environmental law.

Environmental principles also play a role in the administration of environmental law and when exercising administrative discretion.

3.3.1 European Union

EU policies and EU-regulation play a large role in the environmental and health areas in Denmark just as they do for the other EU Member States.

Sources of Community environmental law

The broad definitions of objectives of Community environmental policy, as laid down in the E.C. Treaty Article 2 and 174(1), cover almost any area of environmental policy. Measures to realise the objectives of the Community environmental policy can be based on any relevant Article of the Treaty, although Articles 174 and 175 remain the most relevant provisions for Community environmental action. Thus, measures, which concern agricultural aspects of environmental protection, will normally be based on Article 37 and measures on environmental aspects of transport, on Article 80.

All international conventions, to which the Community has adhered to, is part of Community law. This ranks below the primary law of the Treaty, but above secondary legislation and thus prevails over conflicting environmental directives or regulations[7].

The Community has adopted an important number of pieces of environmental legislation in the form of regulations, directives and non-binding recommendations.

Community powers and Member State powers

In the cases where the Community has not taken action to protect, preserve and improve the quality of the environment, the Member States are free to do so. Limitations to this right to protect – or not to protect – the environment stem from

- the general rules laid down in the E.C. Treaty;
- national rules in the member states;
- rules of international law.

The Member States' competence to deal with environmental measures does not end once the Community has adopted an environmental measure. In order to assess the legal content of a Community measure, it is important to examine exactly what the measure intends to cover. For instance, the Community measure might, for product standards, cover only the standards for those products, participating in the trade between Member States, but leaves the standards for products, which remain in the national market to the Member States. Community terminology speaks, in such cases, of *optional harmonisation.* In contrast to this, *total harmonisation* exists where a Community measure intends to set standards for all products which are put into circulation within the Community, whether they cross a border or not. *Partial harmonisation* only concerns some products, but not all of a given type. *Minimum harmonisation* sets standards at Community level, but leaves the possibility to

[7] An international environmental convention only plays a significant role in Community law where the Community has adopted a directive or regulation in order to transpose the content of the convention into Community law, cf. Krämer 1-07 and 1-08, p. 5.

Member States to fix more stringent requirements. Combina-tions of these types of harmonisation are possible.

Where a Community legal rule conflicts with a national legal rule, Community law prevails, according to the established case law of the Court of Justice.

Also the Treaty itself leaves competence to the Member States to introduce national measures:

Community legislation adopted under Article 175 allows stricter national measures to be taken, cf. Article 176. The nationally more protective measures must be compatible with the Treaty. Measures adopted under Article 176 must be notified to the Commission.

Article 95(4) to (8) deals with the right of the Member States to maintain existing or introduce new legislature measures where the community has legislated on the legal basis of Article 95.

For a Member State to maintain national environmental legislation, a number of conditions must be fulfilled:

a. the Community must have adopted a harmonisation measure;

b. a Member State must deem it necessary to maintain its national legislation on grounds that relate to the protection of the environment;

c. the Member State notifies the Commission of these provisions as well as of the grounds for maintaining them;

d. the Commission approves the national measures.

The conditions for introducing new national environmental measures are relatively strict. They are the following:

a. the new national measure must be based on new scientific evidence;

b. the problem must be specific to the Member State that wishes to introduce the measure;

c. the problem must have arisen after the adoption of the harmonisation measure.

EU leaves to the Member States the question of localisation of polluting industry and activities. Supervision and enforcement is not covered by EU legislation. The protection of the sea and regulation of transport by sea and air[8] is to a great extent regulated by international agreements, where EU does not play a significant role.

[8] Agreements entered into and administrated under the auspices of e.g. International Maritime Organization, Helcom, and International Civil Aviation Organization. Examples of conventions aiming at combating pollution of the sea are the MARPOL Convention, the London Convention and the HELCOM Convention. Not much is done to combat pollution from air transport.

Examples of secondary sources – regulations, directives and decisions
Secondary sources of Community law are the law-making acts of the Community organs, which result in a body of law, generated by the Community itself. Most EU environmental and health secondary sources are directives.

Regulations have a general scope, are binding in their entirety and are directly applicable in all Member States, cf. Article 249. Regulations bind the states and have the force of law in their territories without the need of transformation or confirmation by their legislatures.

Directives are binding as to the result to be achieved, upon each Member State to which they are addressed and the choice of the method is left to the state concerned, cf. Article 249. Directives must be implemented by binding acts, not by advisory circulars. Directives, being commands to Member States, have a significant direct effect upon their addressees. By their designation they have, in principle, no direct effect upon individuals unless implemented into national legislation[9]. Some directives are drafted in considerable detail, leaving little discretion for the Member States.

Decisions are binding in its entirety upon those to whom it is addressed. It may be addressed either to Member States or to individuals or corporations, cf. Article 249.

Danish implementation of EU legislation
Many Danish legislative measures are results of the implementation of EU measures. Examples are the Danish waste regulation[10], regulation on chemical substances and products[11], regulation on ambient air pollution, and regulation on the aquatic environment.

Chemical substances and products have been regulated in many years in Denmark. Since the Danish admission to EU in 1973, the area has been highly influenced by EU measures. EU measures on the area are very comprehensive. EU measures on chemicals are mainly adopted under Articles 94 and 95 (ex. 100 and 100A). Most directives are total harmonisation directives. The main part of the Danish measures is EU measures that have been implemented. The area is now regulated by the Act on Chemical Substances and Products in Denmark.

EU measures on *waste* have mainly been in the form of minimum directives, leaving Denmark to adopt more strict measures. More strict Danish measures have been introduced concerning statutory obligations to deliver waste to waste treatment plants and recycling plants, and waste collection systems. There are three types of EU directives on *ambient air pollution*: air quality standards, air emission standards and quality standards to products such as

---

[9] However, in substance they may well be sufficiently explicit and detailed to make transformation (or transposition) a mere formality and thus take effect even in the absence of implementation.
[10] Dir. 75/442 on waste, amended by Dir. 91/156. The Danish Order on Waste (order No. 299 of 30 April 1997) contains a definition on waste. The definition is an implementation of the EU definition on waste. It was implemented even though the Danish authorities were reluctant in laying down a definition on waste in the Danish environmental regulation. The Danish authorities found such a definition impossible to make.
[11] Dir. 79/117/OEEC, dir. 83/131, dir. 85/298, dir. 86/214, dir. 86/355, dir. 87/181, dir. 87/477, dir. 89/365, dir. 90/335, dir. 90/533, dir. 91/118, dir. 91/414, dir. 88/379, dir. 92/32.

fuel. Directives on ambient air pollution have mainly been in the form of minimum directives[12], which only to some extent have influenced existing Danish legislation. Danish legislation mainly reflects the requirements of the minimum directives. In some cases, Denmark has adopted more strict rules on ambient air pollution. For example, in 1990 Denmark adopted more strict rules on pollution from vehicles. These rules have later been introduced under EU law as directives.

There are three types of EU-directives on the *aquatic environment*: rules to prevent discharge of polluting substances to the surface waters, rules to prevent the indirect pollution of waters (leaking out), and rules to obtain or secure certain use of the aquatic environment and the water. Directives on the areas are mainly minimum directives (with the exception of rules on detergents and cleaning materials). Danish regulation mainly reflects EU-regulation and requirements. The Commission has questioned the Danish implementation of the nitrate directive (91/676) focusing on the need to supplement the Danish legislation to prevent nitrate pollution to fulfil the requirements under the directive. After the introduction of the Danish Action Plan on the Aquatic Environment II, the case has been dropped.

3.3.2 The influence of international co-operation

Transboundary pollution problems, the development towards a more and more open international market, and the increasing need for the sharing of information between countries have increased international co-operation. A large number of international agreements, to many of which Denmark is a Party, have been adopted since the environment was put on the international agenda at the Stockholm Conference in 1973. General principles of international law, meaning principles of rights and obligations of States according to customary international law, require the States to take interest of other States. Danish environmental and health policies and legislation reflect the increasing international co-operation and commitment.

Until recently, health has not specifically been an issue on the environmental agenda in EU or internationally. However, the picture is undergoing a change.

WHO[13] is rather active in linking health and environment. The first WHO European Conference on Environment and Health was held in 1989, hosting the ministers of environment and the ministers of health. The second and the third conference were held in 1994 and 1999. The EU Commission participated at the conferences. At the second meeting, the conference adopted the Declaration on Action for Environment and Health. In the declaration it is agreed that there is a complementarity, not conflict, in the promotion of health and the protection of the environment[14]. Furthermore, it was agreed to co-operate with the bodies of the Environment for Europe in order to promote the inclusion of actions addressing health issues in, or their close linkage with, action plans for the environment and to promote and facilitate the development of joint projects by international organisations at European level[15]. At the third meeting, the conference adopted the Charter on Transport, Envi-

---

[12] With the exception of directives on pollution from vehicles, directives on the content of lead and benzene in petrol and directive on sulphur dioxide in fuel.
[13] World Health Organization, see http://www.who.dk/policy/polstat.htm
[14] Art. 7 of the declaration.
[15] Cf. Art. 11 of the Declaration.

ronment and Health. The Charter promotes sustainable development with relation to the transport sector.

WHO guidelines on the relation between health and pollution is used both nationally and internationally to prepare environmental and health regulations.

For example are the Framework Directive on Air Quality (no. 96/62) and its daughter directives primarily based on WHO guidelines on limit values for air quality for certain substances.

The convention on Access to Information, Public Participation in Decision-making and Access to Justice is the first international accord (in this region of the world[16]) linking human rights to a healthy environment. The Convention was signed in Denmark, and Denmark plays an active role in promoting the Convention.

In general, the Danish Ministry of Environment and Energy earmarks considerable resources for international and EU co-operation concerning environmental, nature and, as a result of the increasing international interest on health, now also health issues.

3.3.3 Principles of Danish environmental law

There are a number of principles that pervade the environmental law, first and foremost the following:

- The concept of *sustainability* is stressed in the Danish environmental acts[17]. Implementation of the objective of sustainability in Danish legislation is to a large extent dependent on the system of decisions and measures, which the authorities - including the management authorities - have to use in the realisation of environmental action plans and legal intentions laid down in statutory rules.

- Another characteristic feature of environmental law is the use of *a holistic approach,* and a relatively *close relation* between the regulations on the environmental area. By holistic approach means that in some decision-making processes it is legal to include a broad spectrum of interests and considerations, including societal considerations. This is most distinct on the area of planning. Localisation of heavy polluting industry and activities is an example of close relation, as localisation considerations shall be taken under both the planning act and the environmental protection act.

- Most Danish environmental legislation contains a rather comprehensive regulation in regard of *supervision and enforcement*. As a result of these regulations, the administrative resources spent on supervision and enforcement in Denmark are extensive. This reflects that the Danish authorities consider environmental protection important, but it also reflects the fact that Denmark, in particular to the middle of the 1980's, has had a lot of problems enforcing environmental regulations.

---

[16] The two other accords are the 1988 San Salvador Protocol to the American Convention on Human Rights and the African Charter on Human and People's rights (International Environmental Law and Policy p. 1317).
[17] Unlike a number of other European countries the concept of sustainability is not laid down in the Danish Constitution. The Constitution has not been amended since 1953 (one of the reasons for this is that the Danish Constitution is very difficult to amend).

- A number of *environmental principle*s - some of them well known from Article 174(2) (former 130(2)) of the EC Treaty - are stated or embodied in the objectives of the Danish acts, see text box 3.1.

Text box 3.1 Principles of environmental action[18]

The polluter pays principle: The polluter pays principle expresses the concept that the cost of environmental impairment, damage and clean-up should not be born via taxes by the society, but that the person who caused the pollution should bear the cost, (Ex: EPA article 4, subsection 3).

The principle of prevention: The principle of precaution together with the principle of prevention primarily means that measures are no longer primarily meant to repair damage or impairment after it has occurred: instead, measures are to be taken earlier, to prevent impairment or damage occurring using Best Available Techniques. (Ex: EPA article 3, subsection 1).

The principle of rectification of damage at source: environmental damage should as a priority be rectified at source, (Ex: EPA article 3 and 4)

The precautionary principle: Preventive measures are taken when there are reasonable grounds for concern that substances or energy introduced directly or indirectly into the environment may bring about damage to human health, harm living, resources, even when there is no conclusive evidence of a casual relationship between the inputs and effects, (Ex: EPA article 3, subsection 2, no. 1).

The substitution principle: The substitution principle gives the importance to include the potential risks and the life circle of a product in the decision-making process, (Ex: EPA article 3, subsection 2, no.2).

Reduction of pollution: The reduction of pollution principle, including best available technology principle and most environmentally friendly technology principle. The most efficient and advanced methods and technology must be used in production, etc. (without entailing unreasonable and excessive costs), (Ex: EPA article 3, subsection1)

The principle of localization: Polluting industry and trade should be localized at places resistant to pollution, (Ex: EPA article 4, subsection 1 and 2).

In Denmark, the authorities are left with broad discretionary powers on the environmental area. Principles of environmental action to some extent delimit the exercising of discretion. As such, the implementation of the principles of environmental action is to a large extent considerably dependent on the choice of decisions and measures taken by the environmental and health authorities in the realisation of environmental and health action plans and intentions laid down in the legislation.

3.3.4 Principles of administrative law

Environmental law is considered a part of administrative law in Denmark. Therefore, environmental law and administrative decisions within the environmental area are subject to the principles of traditional administrative law. The main principles of administrative law are presented in the box 3.2.

[18] The definitions are listed in EC environmental law, p. 9-20 and Danish Environmental Law p. 33-34.

TEXT BOX 3.2 PRINCIPLES OF ADMINISTRATIVE LAW (PRINCIPLES OF JUDICIAL REVIEW)[19]

The principle of legality (Legalitetsprincippet) is twofold. The process of administration may not conflict with the law. Furthermore, it requires that the administrative activity is legitimised by a recognised source - in accordance with the law.

The principle of organisational specialisation (Det organisatoriske specialitetsprincip) prohibits one administrative authority from employing criteria which aim at matters belonging under a different administrative authority

The principle of a substantive specialisation (Det materielle specialitetsprincip), prescribes that an authority which is the administrative body for different laws shall not use its powers under one law to pursue matters which should be addressed under a different law.

Proportionality: According to the principle of proportionality, a public authority may not impose obligations on a citizen except to the extent to which they are necessary in the public interest to attain the purpose of the measure. This requires that there is a reasonable relationship between the ends and the means.

Equality: The principle of equality says that similar cases must be treated equally by the authorities. Only concrete and reasonable grounds (that are grounds based upon central considerations in the law that decision derive from) can underlie a deviation from practice.

3.3.5 Legislative framework

The most important Danish environmental acts related to health are:

- The Environmental Protection Act
- The Planning Act
- The Act on Chemical Substances and Products
- The Soil Contamination Act
- The Water Supply Act.

The Ministry of Environment and Energy administrates all these acts. In the following, a short introduction to each of these acts is given.

The Environmental Protection Act and the Planning Act together with the Act on Nature Protection, are the three so-called fundamental Danish environmental acts. These three acts where adopted in 1973, but underwent a major reform in 1991 as a part of the legal strengthening of the environmental area.

The Environmental Protection Act[20]

The Environmental Protection Act (EPA) is one of the principal environmental acts concerning the protection of the environment and human health. The new EPA entered into force in 1973[21] and has since then been subject to several amendments.

[19] The principles are described in Andersen, Forvaltningsret (Administrative Law), p. 74, 84, 188 and 191.

[20] (Consolidation) Act no. 698 of 22 September 1998 on the Environmental Protection and latest amendments.

[21] The act was a part of a major legislative reform in 1991.

The objective of EPA[22] is to contribute to the protection of nature and environment so as the development of the society is based on sustainability and respect of the living conditions of human beings and for the protection of flora and fauna. It is an act concerning the prevention and combating of pollution; it thus aims at protecting the outside environment - air, water, soil, underground, and the health of human beings - while other acts cover indoor climate and the working environment.

The objectives of EPA are in particular to:

1. prevent and combat pollution of air, water, soil and subsoil, and nuisances caused by vibration and noise,
2. provide for regulations based on hygienic considerations which are significant to humans and the environment,
3. reduce the use and wastage of raw materials and other resources,
4. promote the use of cleaner technology and to promote the development of cleaner products in a life cycle context, and
5. promote recycling and reduce problems in connection with waste disposal.

Art. 2 of EPA lists the activities covered by the act, see text box 3.3.

TEXT BOX 3.3 ACTIVITIES COVERED BY EPA (ARTICLE 2)

Article 2

Subsection 1: This Act applies for:

1) all activities which by emission of solid, liquid or gaseous substances, by release of micro-organisms likely to harm health and the environment or by generation of waste may cause pollution of air, water, soil and subsoil,
2) vibrations and noise,
3) products or goods likely to cause pollution in connection with manufacture, storage, use, transport or disposal,
4) means of transport and other mobile facilities likely to cause pollution, and
5) animal husbandry, pests and other matters likely to cause problems of hygiene or significant nuisances to the surroundings.

Subsection 2: This Act also applies to activities involving hazardous processes and to storage of substances with dangerous properties, in such a way that interruption of operation or accidents may result in imminent risks of pollution as specified in subsection (1) above.

EPA is a framework act, which is to be supplemented by orders and guidelines and to some extent plans. The Ministry of Environment and Energy has adopted a large number of orders and guidelines under the act.

EPA is a general act. Where more specific acts cover certain areas, these acts prevail[23]. EPA is divided in chapters. The more general ones and the ones on expropriation, supervision and enforcement, and provisions concerning ap-

[22] See EPA article 1.
[23] The principle is called Specialia generalibus derogant: Special words derogate from general words.

peal will not be described. For the Danish appeal system, please refer to section 3.4. Besides these chapters, each chapter focuses on the protection of certain media or pollution from certain activities.

1 The protection of soil and groundwater (Ch. 3.): These provisions shall be seen in connection with the Soil Contamination Act. Chapter 3 primarily aims at preventing pollution or the spreading of the pollution. It is prohibited to discharge any products or substances on the ground, which will or might lead to the pollution of the soil and the groundwater. Accidents shall immediately be reported to the supervision authority.

2 The protection of surface waters (Ch. 4): Chapter 4 is connected to the Planning Act. In the regional plan, the county shall lay down directives and objectives for the quality of watercourses, lakes and coastal waters. The municipality shall, in order of EPA, prepare a sewage plan. The sewage plan aims at providing the necessary foundation for the fulfilment of the objectives of the regional plan. It is prohibited to discharge any polluting substances to the surface waters without prior approval from the municipality/county.

3 Polluting industry and activities (Ch. 5): Certain types of polluting enterprises, plants or activities - entered on the list on activities prepared by order of EPA art. 35 - cannot be established or commenced without prior approval from the environmental authority. Neither shall they be extended or modified without prior approval if those extensions or modifications will result in increased pollution (art. 33). Order no. 807 of 25 October 1999 lists the activities to be approved by the environmental authority. Activities and industries, listed in the order, are subject to environmental permit. The environmental authority – county or municipality as indicated on the list - permits the listed activities and supervises compliance with law (art. 33, 35, 65 and 66). Some industries are not subject to environmental permit, but are subject to provisions on notifying to the municipality. The municipality supervises activities that are not subject to environmental permit by the county (art. 65). The county and the municipality shall take action when observing unlawful activities (art. 68). Some heavy polluting industries are subject to provisions on green accounting.

4 Waste (Ch. 6): The municipality is in charge of collection and disposal of municipal waste, and has the responsibility to assign places to the disposal of industrial waste. The municipality shall prepare a waste management plan.

5 Recycling and cleaner technology (Ch. 7): This chapter authorises the minister to provide funding, lay down provisions with the aim of promoting the use of recycling of waste, packaging and products, the use of cleaner technology, and the development of cleaner products in a life cycle context. Provisions concerning obligations to use certain materials in production, recycling systems, etc. can be laid down.

The Planning Act[24]

The Planning Act entered into in 1993 [25]. It has since then been amended several times. The act - and orders and guidelines prepared in order of the act - regulates physical planning in Denmark.

The Planning Act mainly prescribes the powers of authorities, procedural rules and the aims and contents of planning. The aim is to ensure a concerted administration, guaranteeing inter alia that the use of land and natural resources is based on an overall assessment of the community's interests and also taking into account environmental and health issues.

Physical planning is the establishment of goals and policies in specific geographical areas. Physical planning is e.g. protecting different kinds of environmental media. Physical plans are used partly to ensure environmental impact assessments of large plants.

Planning is carried out at three levels: nationally, regionally for each of the 14 counties and locally (as municipal and local plans) in each of the 275 municipalities. This means that planning at any level must be in agreement with the framework established at a higher level.

One of the purposes of planning is to assure opportunity for public participation in land-use and resource decision-making. The plans are available for inspection by advertisement in the Danish State Gazette and the local newspapers.

Many decisions within the environmental law system are made on the basis of planning, either in the form of spatial plans or sector plans. For example, the planning system has an important impact upon the protection of waters - surface waters as well as groundwater – and on the localisation of trade and industry.

The Soil Contamination Act

The Soil Contamination Act[26] entered into force on 1 January 2000, for certain provisions under the act, a bit later. It aims at protecting the soil and groundwater against future pollution from waste deposits, etc.
The Environmental Protection Act regulates the protection of the groundwater. It prohibits the discharge of polluting substances on the ground. However, this is not sufficient as there are already a lot of existing waste deposits or areas where the soil is polluted in Denmark, very often they are situated on areas where there is or have been industry or other polluting activities. The Soil Contamination Act considers these problems.

The objectives of the Soil Contamination Act are:

- Prevent pollution of the soil;
- Monitoring existing pollution of the soil with the aim of preventing further environmental problems caused by the polluted soil; and

---

[24] See the Consolidation Act no. 518 of 11 June 2000.
[25] As mentioned above, the Planning Act is one of the three fundamental Danish environmental acts, which basically were adopted in 1973, but underwent a major reform in 1991. The Planning Act is a compilation of a number of spatial planning acts, which were in force before 1992.
[26] Act No. 370 of 2 June 1999.

- Organise an effective and efficient protection of humans and the groundwater against existing pollution.
- Private owners of property are through an insurance arrangement secured against certain economic burdens resulting from leaking tanks.

Chapter 5 of the Act sets out rules on administrative orders[27] to the polluter.

The competence to give an order on cleaning up the pollution is suggested to be placed with the municipal councils, unless the county councils according to the Environmental Protection Act control the enterprises in question.

The concrete order concerning the cleaning up of such pollution is given to the polluter, and this order can be given irrespectively of how the pollution has happened. It is furthermore without importance whether the addressee of the order owns the polluted premises. If more than one polluter is involved in pollution, a compliance order must be given to all of them. The authority, which has conducted a cleaning up, may sue the responsible persons and businesses for the costs of remedying environmental contamination.

If the addressee of the order cannot freely dispose of the polluting premises, the authorities must give an order to the person who can dispose of the real estate. He can be ordered to tolerate that cleaning up or other measures are taken at the cost of the polluter.

Act on Chemical Substances and Products

The Act on Chemical Substances and Products[28] (ACSP) entered into force on 1 October 1980 and has since been amended several times. The law replaced a law from 1961 on poison and harmful substances and a law on pesticides. It is very closely related to EU-requirements on the area. The ACSP aims at regulating substances and products, which are, or based on, available information, could be considered dangerous for human health or harmful to the environment.

The goal of ACSP is to prevent damage to health and the environment, which may stem from production, safekeeping, use and disposal of chemical substances.

The act covers all chemicals – elements and chemical compounds, both natural and industrial produced – for industrial and for private use. Examples of products covered by the act are paints, cleaning materials, cosmetics, pesticides, biocides and toys.

The minister is authorised to limit or prohibit sale, import and use of certain substances or products.

Very toxic and toxic substances and preparations cannot be sold without a requisition being issued unless the they are sold to hospitals, universities, technical laboratories, doctors etc.

---

[27] The administrative order must be registered on the real estate at the expense of the addressee of the order. Orders concerning the operation of a business must be binding also to future entrepreneurs. An order cannot be given if 30 years or more have elapsed from the time of ceasing of the activity, which caused the pollution.

[28] Act no. 212 of 23 May 1979 on Chemical Substances and Products.

The act and orders prepared under the authorisation of the act lay down rules on classification, packaging, labelling and storage of substances and products.

Furthermore, the act lays down an approval scheme on chemical substances and products aimed at specific purposes, which are further defined in appendix 1 of the act.

Finally, the act lays down rules on a notifying arrangement after which each producer or importer, who wants to sell or import a new chemical substance, before selling or importing, is to report the chemical substance to the environmental authorities.

The Water Supply Act[29]

The objectives[30] of the *Water Supply Act* are to ensure:

1. that the use of water resources takes place according to integrated planning and through comprehensive evaluation of the considerations mentioned in Section 2 of the Act;

2. co-ordination of existing water supplies with a view to an appropriate use of water resources, and

3. extension and operation of water supply network that is adequate regarding volume and quality.

The Minister for the Environment and Energy may in pursuance of the Water Supply Act prepare national plans for water extraction and supply. Important results have been attained under the direction of the county councils concerning the determination of the location, size and quality of water resources as well as the planning of future water use. This has involved the designation of areas crucial for the future supply of water and, indirectly, of areas that are of no interest in that respect.

The county, with the assistance of the municipality, prepares a survey of the water resources in the county; the localisation and volume of the sources, the quality of the water, natural protection of the water resources and description of any sources of pollution. Based on the analysis a survey and an assessment of the water resources available for exploitation is made[31]. Based on the survey and the analysis the county prepares a plan for the use and protection of the water resources. The water resources planning shall be co-ordinated with the efforts concerning soil pollution and soil pollution prevention and repairment[32].

The municipality prepares a plan on water supply, including the localisation of water supply plants and the resources available for the plant[33].
The establishment of a water supply plant and the exploitation of water resources are subject to county or municipality approval.

[29] Promulgation Order no. 130 of 26 February 1999
[30] Cf. art. 1 of the Act.
[31] Cf. art. 10 of the Act.
[32] CF. art. 11 of the Act.
[33] Cf. art. 14.

3.4 Environmental rights

Citizen's environmental rights are granted partly in general laws that regulate all areas of administration, partly in specific environmental laws

3.4.1 Access to information

The Danish Access to Public Administration Files Act[34] contains the general rules on rights of access to documents/files which have been entered into, or drawn up, by an administrative authority as part of the administrative *function* in connection with its activities. This act provides the right of access for anyone who wishes to become acquainted with specific documents or with documents pertaining to specific cases, including those persons or parties that might be involved in a specific case.

The Danish Public Administration Act [35]contains a number of general administrative procedural/litigatory rules, which provide the public with authority in connection with handling of a case. The act addresses, amongst other things, a (person's) or party's right of access to documents. The rules governing a party's right of access to documents contained in this act are more detailed than those in the Danish Access to Public Administration Files Act. If one is denied access to documents because one is not regarded as an interested party, the authority shall, of their own accord, grant permission to access documents in accordance with the Danish Access to Public Administration Files Act.

These acts are of a general nature and regulate all areas of administration.

The following act deals specifically with the environment.

The Danish Access to Files on Environmental Information Act[36] is the implementation of Directive no. 90/31/EEC of 7 June 1990 on free access to environmental information. This act was updated by Act no. 447 in accordance with implementation of the Convention on access to information, public participation in decision making and access to justice in environmental matters (the Århus Convention). The act increases the possibility of access to environmental information by broadening the definition on "public authority", and by narrowing the scope of a number of exceptions. The act generally refers to the regulations contained in the Danish Public Administration Act and the Danish Access to Public Administration Files Act. Anyone can upon request obtain access to information under the act.

There is no standard format for requesting access to information. The request can be made verbally or in writing. The applicant does not need to provide a reason for his request.

3.4.2 Access to public participation in environmental decision-making

Under certain environmental, planning and nature protection acts there are a number of rules/regulations on public participation when a decision has been made.

[34] Act no. 572 of 19 December 1985 on open administration, recently updated by Act no. 429 of 31 May 2000.
[35] Act no 571 of 19 December 1985, recently updated by Act no. 347 of 6 June 1991.
[36] Act no. 292 of 27 April 1994, recently updated by Act no. 447 of 31 May 2000.

As part of the public hearing process, citizens, authorities and organisations have the opportunity to express their point of view before a final decision is made. The deciding authority shall consider these viewpoints and any information received during the hearing. The deciding authority is not required to incorporate (follow) the expressed viewpoints.

All in all, public participation ensures that as much information and as many viewpoints as possible are included in reaching a decision. This is the purpose of public participation; that the best possible decision is made on behalf of the society taking into consideration the interests of those involved.

Examples of areas in which there are rules for public participation:

- Planning (regional plans, municipal plans and council plans)
- As part of the EIA process for heavily polluting industry, extension of existing harbours, recovery of raw materials from the sea bed, coastal installations, certain high speed crafts and ferry routes.
- Municipal sewage planning
- Municipal waste planning
- Preservation of nature, monuments and sites
- Access to the county's examination and remedial action of ground and soil pollution
- Administration of large nature projects
- County approval of the establishing, extension or development of certain heavily polluting industries (listed industries)

Within some of these fields, there are requirements for individual hearings of those persons who are directly affected by any decision made.

3.4.3 Access to justice

When an authority issues a written decision on a particular case, this decision shall be accompanied by instructions for appeal and shall name the authority responsible, the procedure involved in filing an appeal as well as a deadline for receipt of appeals, if any.

There are three independent and impartial appeal boards, which deal with environmental matters: The Environmental Board of Appeals, the Nature Protection Board of Appeals and the Energy Board of Appeals. The Danish Environmental Protection Agency also functions as a board of appeal for decisions on, for example, the Environmental Protection Act. Whether the Danish Environmental Protection Agency is an independent and impartial body is subject to discussion.

The individual environmental acts decide who is entitled to appeal in relation to the administrative decisions made according to the acts. Typically, the addressee and those who have a relevant interest in the outcome of the case can appeal. Furthermore certain societies and organisations are entitled to appeal.

The rules for court proceedings are determined in the Administration of Justice Act (lbk no. 713 of 13/09/1999). Should a citizen or enterprise wish to appeal against a decision made by an authority in court, this shall be done in a so-called civil action. The case can, for example, deal with changes to, or the revoking of, a decision on compensation. The court recognises proceedings, which are instituted by judicial person who has a right of action. Only those persons who have a vested interest in the case are regarded as eligible to instigate proceedings.

Furthermore, it is possible to appeal to the Ombudsman. The idea of an Ombudsman was introduced in the Constitution in 1953. The Ombudsman is nominated by Legal Affairs Committee and then appointed by the parliament. His responsibility is to supervise the national civil and military administration as well as municipal administration. The Ombudsman's responsibility is to ensure citizens civil rights.

3.5 Instruments in Danish environmental and health policy

Public authorities utilise policy instruments to influence people's behaviour. In Denmark a broad range of instruments are applied to secure fulfilment of environmental and health objectives. Some have a delimited field of application, while others have a broad horizontal perspective and is intended at a general level to improve the society's ability to identify and solve problems. This section presents instruments within four categories: integrative, regulatory, economic and other instruments. For a description of these, please see the table next page.

Table 3.4 Definition of four types of instruments in environmental policy

Type of instrument	**Description**
Integrative instruments	Instruments that seek to integrate environmental and health concern into society's overall planning, into decision-making, into sector policies, and into organisational behaviour. These instruments are applied in order to re-direct the societal development towards sustainability. They are sometimes termed "horizontal measures".
Regulatory instruments	Legal instruments that establish appropriate and non-appropriate behaviour for the citizens. Legal instruments lodge on appeal with appropriate behaviour and the threat of being punished if not observing the rules.
Economic instruments[37]	Instruments, which may influence environmental and health outcomes by changing the cost and benefits of alternative actions open to economic agents. They aim to do so by making the preferred action financially more attractive. The term "economic instruments" thus also includes subsidies, etc. that have a positive environmental and health impact.
Informative and other instruments	Those instruments aimed at the production of new knowledge on health and environmental performance and conditions in order e.g. to raise the awareness of environmental and health problems.

[37] Please note that economic instruments actually are a certain type of integrative instruments as the purpose of applying such instruments is to influence individual and policy choices in a broad range of economic and social spheres. They could therefore have been placed as a subset of integrative instruments. However, here they are placed as particular type of instruments as they have in common that they seek to improve the environment by creating a “green” economic incentive structure.

3.5.1 Integrative instruments

When the United Nations World Commission released its report *Our Common Future* in 1987 it acquired a significant role in the Danish debate on environmental policy, and it provided the starting signal for integration of environmental policies into other sectoral policies.

This attempt has hitherto been partly successful.[38] A number of innovative instruments have been institutionalised in recent years just as progress has been made in improving sectoral integration at the planning, budgeting and project levels.

Several sectoral action plans have been prepared since the early 1990s, and one of the main objectives is that environmental concern must be firmly anchored in sector policies. The plans, which actually could be seen as a type of integrative instruments, have accelerated the introduction of integrative instruments.

The most recent plans are action plans for transport, agriculture, energy, forestry, waste, chemicals, and the strategy for a product oriented environ-mental strategy.

In the following, the prominent integrative instruments are briefly introduced.

- *Strategic Environmental Assessment of bills presented to parliament. Ac*cording to a 1993 government decision, all bills presented to the Parliament must undergo an environmental impact assessment and those with major environment effects must include a description or assessment of the expected environmental impact; along with other impact assessments (e.g. administrative costs). The ministries that prepare a bill or policy proposal presented to Parliament carry out the assessment themselves. They use guidelines from the Ministry of Environment and Energy to establish the assessment.

- *Strategic Environmental Impact Assessment of national budget.* The above mentioned requirement in regard of assessment of bills also applies to the national budget. The government has since 1997 carried out an evaluation of the environmental impacts of the national budgets. The assessment does not cover all aspects of the national budget, but aims at assessing the overall impact of the budget.

- *"Green" public procurement.* A voluntary agreement on public green procurement was made in 1998 between the National Association of Municipalities and the Minister of the Environment and Energy. The National Association of Municipalities has recommended the municipalities to develop Municipality policies on green procurements. A vast majority of public institutions have an environmental policy that takes into account environment and energy friendly procurement considerations.

- *International assistance.* Environmental and health concern has been incorporated in the general Danish development policy and international assis-

[38] Based on the official Danish reporting to the United Nations' Committee for Sustainable Development, the attempt to integrate environmental concern into sector policies has only been partly successful. The Danish authorities have thus attributed a rather low score on the indic a-tor called "Integrating Environment & Development in Decision-making" . See http://www.un.org/esa/agenda21/ na tlinfo/countr/denmark/inst.htm.

tance programmes during the 1990s. This is the case both for assistance carried out bilaterally as well as multilateral via the UN, the European Union and the international development banks. Moreover, Denmark provides specific environmental assistance to a number of developing countries and countries in the Central and Eastern Europe. In total, the Danish official development assistance exceeds 1% of the GNP.

- *Environmental Impact Assessments*. The EU-directive on EIA has been implemented in Denmark. Private as well as public projects, which is assumed to impact on environment, can be realised first after the passing of an EIA.

- *Agenda 21 plans at municipal level.*[39] The Ministry of Environment and Energy, the National Association of Local Authorities in Denmark and the Association of County Councils in Denmark are partners in the joint campaign for local Agenda 21. At present 70% of the Danish municipalities are working with local Agenda 21. Following the concept of thinking globally and acting locally, the purpose of the campaign is to strengthen local environmental efforts. The Danish Parliament passed legislation in February 2000 requiring all counties and municipalities to publish a report outlining their strategy for local Agenda 21 at least every 4 years.

3.5.2 Regulatory instruments

Regulatory instruments are the most common used policy instrument. There are several types of such instruments of which the most important are described in this section.

Norms
Norms are typically set down in legally binding rules (e.g. limit values, standards) or in guidelines (e.g. quality criteria). Norms set down in guidelines are used to lay down conditions in permits, approvals, orders, etc. There are different types of regulation by norms within the environmental area:

- *Limit values for emissions:* Limit values for how much pollution it is admitted to discharge. (Example: Limit values for mercury per m^3 water discharged by industry).
- *Limit values for immissions:* Limit values for how much pollution it is admitted to cause on nature or environment. (Example: Limit values on how much noise from trade and industry may cause on nature and environment in certain areas).
- *Quality criteria:* Quality criteria to the media, which is subject to the discharge or contamination from the polluting activities. (Example: Soil quality criteria for chemicals considering most sensitive uses of the soil i.e. domestic gardens, kindergartens).
- *Production norms:* Norms to the production potential, production process and the finalised product. (Example: Conditions on animal husbandry concerning the storage of droppings and the spreading of droppings.).

---

[39] The Ministry's local Agenda 21 campaign is based on Chapter 28 of Agenda 21. Chapter 28 says that the local authorities are responsible for implementing Agenda 21 in cooperation with the local population. The Ministry's campaign therefore targets the counties and municipalities so that they can translate the Agenda 21 principles into local action.

Approval, obligation of notification, obligation to act, etc.
Some activities need prior approval or permit before they can be carried out. Environmental and/or health related conditions are laid down in the approval or permit to carry out a certain activity. The industrial production is primarily regulated by an environmental permitting and notification system under the provisions of EPA, see text box 3.4.

TEXT BOX 3.4 ENVIRONMENTAL PERMIT

Certain types of polluting enterprises, plants or activities – entered on the list on activities prepared by order of EPA art. 35 - cannot be established or commenced without prior approval from the environmental authority. Neither shall they be extended or modified without prior approval if those extensions or modifications will result in increased pollution (art. 33). Order no. 807 of 25 October 1999 lists the activities to be approved by the environmental authority. Activities and industries, listed in the order, are subject to environmental permit. The list covers activities listed under the IPPC-directive and a number of other so-called heavy polluting activities.

The environmental authority – county or municipality as indicated on the list - permits the listed activities and supervises compliance with law (art. 33, 35, 65 and 66).
The environmental authority is by order of EPA art. 34 authorised to lay down environmental, including health-related conditions in the approval in order to prevent pollution. Several orders and guidelines specify requirements, limit values, etc. to be laid down on specific activities under the approvals.

If a plant/activity is subject to both an EIA and environmental permit, then an environmental permit cannot be issued before the EIA has been approved.

The permitting system covers about 7,000 industries.

Some activities are permitted if they have been notified in advance. They do thus not need prior approval as such. Rules on notifying do not lead to the same into depth administrative investigation of the polluting activities as permits and approvals do. Rules on notification aim at informing the authorities, at an early stage, on activities that might involve risks - thereby securing the possibility to intervene to prevent pollution of the environment, or to prevent emissions of substances injurious to health.

For more information on notifying, please see the following text boxes.

TEXT BOX 3.5 NOTIFYING NON-LISTED ACTIVITIES

Certain types of enterprises, plants or activities – entered on Order no. 367 of 1992, amended by Order no. 358 of 1993, on Non-listed Activities shall notify the environmental authority prior to the establishment, commencement or extension.

The environmental authority is the municipality, which also supervises compliance with law.

The notifying system of non-listed activities covers about 14,000 industries.

For some activities, the user or owner of a property or the environmental authority is under the obligation to act:

Text box 3.6 Inform about pollution or risk of pollution

The user or owner of a property is obliged to inform without delay the environmental authority if he/she causes or notes pollution of the soil or the underground, cf. EPA art. 21.

Text box 3.7 Correct illegal activities

The supervision authority is under the obligation to correct illegal activities, unless the matter is quite insignificant, cf. EPA art. 68 and 69.

Plans

Regulation by plans is quite common within the environmental area. Plans are suitable for taking into consideration a more holistic approach. Also, they enable public participation in decision-making and consideration for sector interests.

The influence of plans on the administration of the environmental and health area is primarily a result of their use as means for general guidance on the area. Also they play an important role for co-ordination of the use and disposal of land.

Environmental agreements

Agreements are considered having the advantage that the industry is supposed to be more accepting and loyal towards an agreement than towards norms, rules, etc. Further, it is assumed that regulation by general rules is sometimes less efficient when the aim is to reduce the overall pollution within a certain area.

The Environmental Protection Act article 10[40] entitles the authorities to enter into legally binding agreements with industries or unions of industries. Further, the authority is entitled to lay down provisions on those industries, which are not willing to enter into an agreement. The minister decides the level of pollution/the level of reduction of pollution. What is negotiable are the means to obtain the reduction of pollution. In practice it has been very difficult to reach environmental agreements. Among other things, it requires a structured branch to reach agreement. There has only been made one agreement[41] in order of EPA Art. 10. Voluntary agreements are another tool. It is a sort of a "gentleman agreement" and cannot be brought for the Court or the Board of Arbitration. The Ministry of the Environment and Energy has at present concluded 13 voluntary agreements with industrials associations[42].

Also at county and municipal levels gentleman agreements are sometimes made between industry and trade and the public authorities. There is no general overview of these agreements.

[40] The provision was introduced in 1991.
[41] Agreement of March 21, 1996 between the Minster and the Danish Society for the Collection of Lead Accumulators.
[42] Examples are the agreement of April 3, 1991 between the Minister and a number of societies representing industry and trade concerning PVC and the Agreement on VOCs.

3.5.3 Economic instruments

Denmark makes extensive use of economic instruments in environmental protection. They were explicitly introduced into Danish environmental policy in the mid-1980s. Since then, the use has increased. There are several types of economic instruments like fees, charges, taxes, etc.[43] They also include instruments actively supporting certain types of behaviour (subsidies, granting of loans).

Taxes, fees, etc.

Although the Danish green taxes and energy taxes are meant to influence the behaviour of enterprises and of individuals, some of them are also a source of finance for public (environmental) activities. It is therefore common to distinguish between:

- *Economic instruments* that originally did not have an environmental objective like vehicle and energy taxation. Some of these have been re-designed in recent years so as to reflect the environmental impact more accurately.

- *Green economic instruments* dating back, primarily, to the so-called green tax reform in 1993/94 having as main objective a gradually shift of the tax system away from income taxation towards environmental taxes.

In 1998, economic instruments all together contributed 16% of total government tax revenue. However, the revenue from the green economic instruments made up only 3% of the total government revenue. Income taxes and other indirect taxes (like VAT) are thus still the main sources of government budget.

A particular environmental tax would typically affect more than one environmental medium and more than one economic sector. For example, waste taxes affect households and industry, and to the extent that they affect waste volumes, this may impact positively on the quality of air, soil, and groundwater. The bulk of the instruments are targeted at either air, or soil and groundwater.

For further information, see appendix 2: Overview of economic instruments in Denmark.

Apart from the instruments mentioned in the table, certain regulations lay down liability for environmental damages on an objective basis (strict liability) [44]. These regulations can be considered as a sort of economic instrument. Strict liability means that the person or legal entity does not need to have shown negligence to be deemed liable for the damages. Strict liability provides an incentive for taking measures to prevent damage from occurring in the first place. An example is *Act on Liability for environmental damages*. The Act

---

[43] *Taxes* are compulsory unrequited payments to the government. *Charges* are compulsory required payments. These are proportionally related to the services provided. *User fees* are payments for specific environmental services such a waste disposal and the fee shall reflect the costs of providing the service.

[44] Danish law on liability and compensation for environmental damage resulting from activities dangerous to the environment or health is for the most part unwritten law - ordinary principles (the culpa rule) laid down by the courts. The culpa rule implies that an enterprise, a person, or other legal entity almost always has to pay damages for a pecuniary loss that it has caused to other persons or legal entities by negligence.

stipulates that the liability for environmental damages caused by particular polluting enterprise will be prosecuted on an objective basis. Furthermore, there are rules on strict liability concerning soil pollution, nuclear power plants, maritime transport of oil, and transport by road, rail and air.

Subsidies

The Danish use of subsidies serve many different purposes and are targeted at different groups of society. Some of the subsidies relate to the environmental media directly, while others are targeted at specific economic sectors. For example, there are subsidy schemes that aim to improve the state of the aquatic environment, while other schemes are specifically targeted at the agricultural sector. There are also subsidies with a very general scope, such as aiming to promote cleaner technology.

New environmental regulations are often accompanied by the launching of subsidy schemes to offset part of the negative financial implications of the regulations in question. In recent years, subsidies have tended to be framed in a steadily more strategic manner targeted towards innovation in technology and life styles. Examples hereof are subsidies to promote organic agriculture, environment friendly technologies and lifestyles and cleaner products.

Most subsidies in Denmark are characterised by being temporary with a lifetime of 5-10 years. The time constraint is considered important to accelerate the effects. Subsidies are sometimes coupled with overall environmental policy targets and macro-economic objectives. Among those are energy subsidies that assist to enhance Danish energy self-sufficiency.

The subsidies often constitute part of a broader policy-package where environmental taxes are introduced simultaneously with related subsidy schemes. Denmark, however, never applies a direct coupling, in the form of earmarking of revenue from taxes and charges on one hand, and the provision of subsidies on the other hand.

In 1998, a total sum of MDKK 3,090 was allocated to environmental subsidies. The energy sector is the most important receiver of subsidies, accounting for 68% of the total budget allocation for subsidies. The rest is distributed to water, waste recovery, agriculture, cleaner technology, etc.

3.5.4 Informative and other instruments

This section describes instruments that aim to promote environmental and health objectives via raising the awareness of environmental and health problems and by providing information on environmental factors in relation to health.

- *Environmental information and campaigns*. Information to the public on the environment has a high priority, and the Ministry of the Environment and Energy devote in the range of 55 person-years to provide environmental information to the public. Several publications, ranging from scientific reports to educational materials are published every year.

- *Environmental labelling*. The aim of environmental labelling is to stimulate a more environmental friendly consumption by guiding and informing consumers. EPA article 8 entitles the Minister to lay down rules on environmental labelling when selling products, etc. Labelling can be used on products, goods, etc. that contain recycled material or if there are other environmental reasons to prefer the product compared to other products for the same use. Denmark has joined the Nordic Swan Label and the EU Flower Label.[45] Rules on the labelling are laid down in Order no. 35 of 19 January 1998.

- *Green accounts*. There are two aims of green accounting. The first is to provide the authorities and the public with information on how the polluting industry influences the environment and health. The second aim is to inspire the industry to consider environmental issues when choosing raw materials and resources, and when choosing production processes. Order no. 975 of 13 December 1995 on Green Accounts regulates the Danish environmental auditing. Certain types of polluting industries are subject to publish a yearly green account. Examples of information, which have to be given are account on the consumption of energy, water and raw materials, which have been expended in the auditing period. Account on polluting substances, etc., which have been used in the production processes; have been discharged or emitted to air, water or soil form part of the final products; or are included in the waste from the industry. The green account is available to the public in accordance with the Danish regulation on access to information.

- *Green auditing*. Green auditing has been completed for a number of ministries, state-owned forests and the national railways.

- *Environmental management and certification, etc*. Environmental management (e.g. EMAS and ISO) is a part of the industry's voluntarily effort to improve their environmental performance. Since 1995, the Ministry of the Environment and Energy has supported initiatives developing environmental management by economic support to projects.

- *Danish implementation of the Directive on the Freedom of Access to Information on the Environment*[46] (and the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters) can be considered as more process orientated and informative instruments.

- *Information to branches*. The Ministry of the Environment and Energy regularly issues orientations to certain branches of trade and line of businesses concerning on recent knowledge concerning the environment, environmental performance and management.

3.6 References

Literature

Moe, Mogens (1997): *Miljøret* (Environmental Law)

Basse, E.M. (1999): *Miljøret* (Environmental Law)

Basse, E.M. (2000): *Environmental Law - Denmark*

Revsbech, Karsten (1999): *Lærebog i miljøret*
(Textbook in Environmental Law)

[45] Cf. Council Regulation No. 880/92 of 23 March 1992.
[46] Council Directive 90/313/EEC of 7 June 1990.

DEPA (1999): "*Economic Instruments in Environmental Protection in Denmark*".

Jänicke, M. & H. Weidner, eds., (1997): "*National Environmental Policies. A Comparative Study of Capacity-Building*", chapter on "Denmark"

Krämer, Ludwig (2000): *EC Environmental Law*

Ministry of Environment and Energy (1995*): "Environmental Administration in Denmark*", by Mogens Moe

Ministry of Environment and Energy (1999): "*Natur- og miljøpolitisk redegørelse 1999*". (The Danish Nature and Environmental Policy).

OECD (1999): "*Environmental Performance Review, Denmark*"

Jon, Andersen (1999): *Forvaltningsret* (Administrative law)

Homepages

Ministry of Environment and Energy (2000): Homepage, http://www.mem.dk

Ministry of Food, Agriculture and Fisheries (2000): Homepage, http://www.fvm.dk

Ministry of Health (2000): Homepage: http://www.sum.dk

The Nature Council (2000): Homepage, www.naturraadet.dk/

Confederation of Danish Industries (2000). Homepage, www.di.dk

The Association of Danish Power Plants (2000). Homepage, www.home7.inet.tele.dk

Danish Society for Conservation of Nature (2000). Homepage, www.dn.dk

The Ecological Society (2000). Homepage, www.ecocouncil.dk

World Health Organization, Denmark (2000). Homepage: www.who.dk/policy/polstat.htm

The Consumers Society (2000). Homepage, www.fbr.dk

Danish legislation

The Environmental Protection Act, cf. Consolidation Act no. 698 of 22 September 1998 and later amendments.

The Planning Act, cf. Consolidation Act no. 518 of 11 June 2000.

Statutory Order no. 807 of 25 October 1999 on listed activities to be environmentally approved.

Order no. 367 of 1992, amended by Order no. 358 of 1993, on Non-listed Activities.

Act no. 370 of 2 June 1999 on Soil Pollution.

Act no. 212 of 23 May 1979 on Chemical Substances and Products.

The Water Supply Act, cf. Promulgation Order no. 130 of 26 February 1999.

Act no. 572 of 19 December 1985 on open administration, recently updated by Act no. 429 of 31 May 2000.

Act no. 571 of 19 December 1985 on Public Administration, recently updated by Act no. 347 of 6 June 1991.

Act no. 292 of 27 April 1994 on access to Environmental Information, recently updated by Act no. 447 of 31 May 2000.

<u>EU legislation</u>

The EC Treaty

Directive no. 90/31/EEC on free access to environmental information.

Council Regulation no. 880/92 of 23 March 1992.

Directive no. 90/313/EEC of 7 June 1990.

4 A historical overview of environmental policy in Denmark

This chapter provides a historical introduction to present-day environmental policy in Denmark highlighting main events and trends in the policy development and debate since the first emergence of an environmental awareness around 1960.

The overview is divided into three different historical eras beginning around 1960. The eras are structured according to major changes in the environmental policy. The categorisation should not be interpreted rigidly. There are many overlaps between the three eras just as the exact delimitation of the eras probably could have been different. Still, they capture significant characteristics of the historical development of the environmental policy in Denmark. The eras are titled as follows:

- *Initial recognition of health and environmental problems (1960-1972).* A growing industrialisation in the Danish society results in a large increase in pollution in comparison with the previous decades, and the Danes become aware of the potential health-depreciating effects of pollution. Environmental problems are thus discovered, discussed and acknowledged. The focus at this point in time is limited to local pollution problems. This era is dominated by a health-oriented concern in relation to environmental problems.

- *Implementation of comprehensive environmental regulation (1973-1991).* In the second era a Ministry of Environmental Protection[47] is established and the first comprehensive Environmental Protection Act in Denmark came into force. A comprehensive regulation is elaborated and implemented during this period and there is also an increasing use of overall action plans outlining environmental objectives. The international aspects of environmental problems are being recognised. As the European integration speeds up during the 1980's, the European Union becomes a still more important arena for environmental and health policy making, Denmark being a member since 1973.

- *Prevention of environmental problems (1992-1998).* This era is a consequence of the new Environmental Protection Act of 1992. The focus is on individual responsibility and the period is moreover characterised by a focus on the prevention of environmental and health problems, and an intense interest in the regulation of international environmental problems.

For an overview of the three eras please see Table 4.1 in Section 4.4. The pre-1960 period is the very early stage of the Danish pollution control story, and will not be described systematically in this chapter. However, text box 4.1 provides a brief overview.

[47] At the time of formation the name of the ministry was Ministry of Environmental Protection. In 1994 the ministry changes name to Ministry of the Environment, and in 1995 the ministry was given its present name namely the Ministry of Environment and Energy.

Text box 4.1 The early story of pollution control in Denmark (the pre-1960 period)

Under the impression of the 1853 cholera epidemic, the national parliament decided in 1858 to establish health committees in towns and cities. They should be entrusted with the constant supervision of all maters relating to health and hygiene. This legislation, with subsequent amendments, actually formed the basis for a substantial part of pollution control until the adoption of the Environmental Protection Act in 1974. Hence, not until the 1960s, the time was ripe for a thorough revision of the 1858 legislation on health commissions.

Copenhagen, in particular, suffered from heavy pollution after the middle of the 19th century, and the city council was forced by the national authorities to adopt significantly tougher health bylaws. The requirements concerned e.g. the design and location of wells and sewers; the design and cleaning of streets; the removal of household waste; the design of latrine pits; limitations of industries considered hazardous to public health or to their workers, for instance, bone meal and glue factories, slaughterhouses and chemical factories.

The most important initiative in the pre-1960 period, seen from a health perspective, probably was the construction of sewerage systems.

Until 1960, pollution was seen as isolated and local problems between neighbours, rather than a more general problem of concern to the society as such.

The case of regulation of toxic substances and pesticides demonstrates this attitude. As of around First World War, Danish agriculture began to apply chemicals more systematically. In 1932, the Ministry of Agriculture introduced an act on substances in the view of controlling plant diseases. The main objective was to exclude fraud in order that consumers could be sure that the effect of pesticides was sufficient. In 1948, the ministry also endeavoured to ensure that the pesticides contained sufficient volumes of active substances, and it was not before the beginning of the 1950s that the Danish National Board of Health warned the Ministry of Agriculture that the substances may have hazardous effects on human beings. But this made hardly any impression on neither civil servants nor on politicians. Pollution was not yet perceived to be a societal problem.

Source: Jens Engberg (1999b): *For The Common Weal.* The story of pollution control in Denmark from the 1850s to 1974, City of Copenhagen, Miljøkontrollen.

4.1 Initial recognition of health and environmental problems (1960-1972)

Up through the last century, pollution from industry and private households increased dramatically. From 1960 and onwards, industry and mass production became part of everyday life; provided better material conditions for the Danish people and the standard of living improved. Items like private lavatories, a fridge, own car and a central heating system in the house soon became part of many people's daily life.

People were not used to consider environmental effects in relation to their private consumption and their desire for an increased standard of living appeared to overrule anything else. It was the general understanding that the new standard of living of the 1960s could not be questioned.[48]
The environmental consequences started to show up in the form of increased pollution of the lakes and the sea, a high level of noise and air pollution from e.g. the heating systems, the different means of transportation, and also a significant increase in the amount of waste disposal.

The improvements in the standard of living was the heavy increase in pollution, which the Danish legislative system at that time was not prepared for at all, as regulation in environmental areas rested on health regulations initiated in 1858.

[48] See Jamison et.al: 1990; p.72.

Internationally, this period saw the publication of what later has been termed the first modern publication on environmental problems namely Rachel Carson's *Silent Spring* in 1962; a book written to alert the public and stir people to action against the abuse of chemical pesticides. The book was read with interest, also in Denmark.

4.1.1 Waste disposal

The increase in standard of living at that time entailed a more widespread use of e.g. chemicals and petrol and an increase in the complexity in waste disposal.

The first problem was dealt with in various ways. Some of the fluid waste was lead into the sea, because the waste then would be absorbed in the large amounts of water. Other initiatives were to burn of the fluid waste. However, none of the initiatives seemed to be an acceptable solution in the long run and in 1971 the municipalities agreed jointly to start up a plant in Nyborg, with primary purpose of regaining or incinerating the different types of chemicals. The plant called "Kommunekemi" and located in central Denmark is still the largest receptor in Denmark of chemical waste and it is only through the last decade that competing receptors have entered the market.

At the same time plastic and paper had become a significant part of the waste disposal and therefore it was not only the amount of waste disposal but also the complexity that gave rise to concern. The most appropriate solution (at the time) was found in burning of the waste. Therefore two refuse disposal plants were build in Ejby and Amager (suburbs to Copenhagen), which in 1970 were ready to eliminate waste from the Copenhagen area.

4.1.2 Wastewater

Pollution caused by wastewater resulted in a considerable inconvenience for the public health in Denmark in the form of e.g. reduction in bathing water facilities due to pollution of coastal areas and fresh water pollution. But concern was also raised as to the more direct health effects. A study initiated by the Ministry of Agriculture and published in 1966 stated that discharges in built-up areas entailed high risks of infectious agents, which could lead to paratyphoid fever, mouse typhus, polio and jaundice. The highest risk was connected to discharge from hospitals, incinerating plants and slaughterhouses.[49]

Regulation of discharge and freshwater resources was legally placed in the Ministry of Agriculture, which many people saw as a contradictory situation since farmers were contributors to pollution of lakes, streams etc. In 1949 a new law for wastewater was effectuated. It provided the municipalities with an obligation to push charges on polluters of freshwater areas if the pollution led to depreciation of the public health.

In 1963 the law was no longer sufficient. The pollution of the freshwater with large amounts of infectious matters and a growing discharge of chemicals had now reached a stage that was not acceptable. A new law was implemented in 1968. It deviated from the prior law as it included issues concerning the freshwater areas, the sea and the drinking waters supplies.

---

[49] See Engberg, 1999b: p. 43.

Already in 1967, the Minister of Agriculture argued that "*one has to make a serious effort against discharge contamination by protecting lakes, water streams and beaches from discharge pollution to such an extent that those important parts of our surroundings can be preserved as a common good and be passed on to our descendants in a decent condition*".[50] Unfortunately, the good intentions were not followed by actions.

By 1970, one third of all wastewater was lead into the environment without any kind of purifying. More than 2,000 wastewater treatment plants existed at the time from which 1,500 were only mechanical systems and 500 also included biological treatment of the wastewater.

4.1.3 The environmental movement

In the mid-1960s, the number of complaints about pollution and the lack of governmental commitment increased. The Danish newspapers started different campaigns to harass the local politicians and the general awareness increased of the consequences of the pollution. One issue for the papers was the visual pollution i.e. smog, pollution of the bathing water at the seaside resorts etc.

The only environmental grassroots at that time was the Danish Conservation Society, who advocated for the recreational effects: *"Pollution of our lakes and seas have an influence on all of us. As they become dangerous to our health, they become unsuitable as re-creative areas"*(Mikkelsen, DN, 1965; p.8). Thus, environmental conservation was necessary for the people due to public re-creative interests.

From the late 1960s, the political left wing in Denmark had success with their societal criticism in which they defined environmental issues to be an integrated issue. In 1969, a group of political leftwing students started the grassroots movement NOAH. Their conceptualisation of the environmental problems focused on "pollution as a central problem simply because it threatened the survival of humanity".[51] Therefore they argued that pollution should be prevented in all cases. Because NOAH was organised mainly among students within natural science, the organisation had an in depth knowledge of the environmental effects of pollution. They set their own standards and were not satisfied with the national nor the international efforts.

4.1.4 The political initiatives

In the attempt to avoid health-depreciating conditions for the Danish citizens, various initiatives were established. Some of the major initiatives are presented here. They can all be seen as political steps that eventually would lead to the establishment of the Ministry of Environmental Protection.

Health Commissions
Health Commissions were established at municipal level and they were closely connected to the municipalities. The commissions were responsible for individual health and safety permits to companies, stores and production plants in its regulatory area. Their authority thus included health conditions in small

[50] See Engberg: 1999a, p.274.
[51] See Jamison et.al.: 1990; p.80.

shops as well as production permits for large international oil companies. The authority of the commissions was rather extensive, which unfortunately did not correspond with their competence and insight to the environmental effect of chemicals, special types of products, and in general handling of the new type of pollution. The establishment of the commissions was seen as an important political step, but the actual effect was difficult to detect since the commissions often had to rely on what was called a sound judgement simply because of lacking expertise in the commissions.

Another problem was that the structure of the commissions made it difficult to effectuate regulatory progress, especially across the borders of the single municipalities. An example was Øresund; the sound between Denmark and Sweden. Many municipalities were draining all wastewater into Øresund and one by one the swim facilities closed along the coast. Since no single actor could be held responsible, nothing was actually done to prevent the enormous pollution, besides an establishment of a commission. This commission was organised in 1957 to evaluate optional ways to reduce pollution from drains into the sea and in 1964 no results had been presented and no following up had been initiated despite a very emotional debate about the recreational effects of the pollution (Jensen: 1996; p.197).

Hygiene Commissions

In an acknowledgement of the missing results from the Health Commissions in 1964, a new type of commission was established, the Hygiene Commission. Unlike the Health Commissions this commission consisted of high level civil servants from every relevant ministry, national board or directorate of the Danish government.

One of the main purposes of the new commission was to supervise de-central Health Commissions and to bring forward new ideas to avoid further environmental and health deterioration.

Another mission for the new commission was to co-ordinate existing rules in the areas of water supply and the recreative aspects of water such as lakes, sea, water streams etc. But their mission was also to set up propositions for new methods to overcome the growing pollution. In 1970, the commission presented a thorough report in which propositions for the future work of the Health Commissions were dealt with. The report uncovered aspects crucial to the understanding of later initiatives in the health area. They were the following:[52]

- The report assessed that regulations concerning health deviated significantly among the municipalities. This made them difficult to administrate and difficult for the citizens to understand the current status.

- There lacked a precise definition of the terms *health* and *danger for health* also at the central governmental level, and this made it difficult to perform concise regulation within this field.

- The report noted that the close interconnection between the Health Commissions and the municipalities made it almost impossible to take national initiatives or to start up activities across a couple of municipalities.

- Finally, the set-up of the Health Commissions often resulted in situations where the local mayor had one priority of the use of existing resources in

[52] See Engberg: 1999a.

the municipality, a priority which often deviated from the one of the local Health Commission.

A reform took place in 1970 in the municipal set-up, whereby small municipalities merged and the municipal level of authority was subsequently increasing its governmental impact especially in the field of health and pollution oriented aspects. The changes not only concerned the municipalities as also the County level gained more influence. As a consequence, the Hygiene Commission presented a regulatory set-up, entailing that the Counties should establish individual Hygiene Commissions to secure co-ordination within their jurisdiction. They should also provide counselling to their Health Commissions at the municipal level.

The national Hygiene Commission was becoming too large and unable to get the necessary work done and moreover not able to change their traditional way of thinking. As a way to overcome the inefficiency, a new group was established in 1969, the Provisional Pollution Council - an initiative, which in the longer run lead to the abolition of the Hygiene Commission.

Provisional Pollution Council

The council was the first step towards a Ministry of Environmental Protection. It was rather radical in its approach in comparison to the prior initiatives. In 1971 the Provisional Pollution Council presented a working paper where the ineffectiveness that bureaucratic organisation historically had led to in respect to environmental and health-oriented issues was the main focus. The council advocated for an integration of the various initiatives and presented a structure, which more or less characterised the governmental structure, as we know it today in this area.

At this point in time, there was also an important external influence from international initiatives and efforts made in other countries. The United Nations held the first environmental conference in Stockholm in 1972. It received a lot of public awareness and contributed to establishment of national environmental ministries in most of the West-European countries.

Moreover, the so-called Rome club published the radical "Limits to growth" report. The authors set up a model to measure the remaining natural resources left in the world and argued for a highly restricted use of these resources. This way to present the environmental conditions caught the attention of a much larger part of the society. Suddenly environmental concern was no longer just an issue for the most critical and intellectual part of the population.

4.1.5 The dominant environmental understanding

In the beginning of this period, nature was primarily seen as a common free good for everyone to exploit. Many people and companies did. Waste, discharge and chemicals were let into the natural environment, and the Danish people were keen to protect the material progress they had achieved.

On the other hand, effects on the health conditions managed to become a prevailing issue. Complaints about pollution appeared daily in the news, and the environmental problems were no longer just accepted and interpreted to be an unavoidable effect of industrialised society. Instead the authorities and the polluting actors were held responsible for the pollution.

The Hygiene Commission presented in their report in 1970 the first example of an environmental understanding as the one that we have today, but it was never implemented due to the replacement of the commission by the Provisional Pollution Council.

In the beginning of the 1970s, the growing awareness of the effects from pollution and the growing intensity in the debate made it clear that pollution was an area, which would gain a central role in the political field.

To sum up, from 1960 and onwards, pollution became an every day issue in Denmark. A growing number of citizens felt an actual threat towards their health and they expected the government and local authorities to take action. This response to pollution illustrates the structural set-up in Denmark, where the governmental authorities play a central role in people's mind and turned upon when response to public concern is required.

4.2 Implementation of comprehensive environmental regulation (1973-1991)

During 1973-1991, the efforts required within the environmental sphere were being effectuated to some extent. The first Danish Environmental Protection Act was to prove its value, and environmental authorities had to step into focus to avoid further exploitation of the environment. Since the late 1980s, the concept of sustainability became an important guideline for the design of environmental policy. It implied an interest in preparing comprehensive action plans just as the idea of sector integration of environmental concern was highlighted.

4.2.1 The regulatory set-up

The Ministry of Environmental Protection was established. It was organised in line with the propositions made by the Provisional Pollution Council, and the new Minister was the former leader of the Council. Shortly after the rise of the new ministry it was decided to end the council's activities. However, there was still a need for a more action-oriented authority to supervise and coordinate the regulatory activities at the county or municipality level and already by the end of 1971, a new agency was established, the Danish Environmental Protection Agency.[53]
As described above, there was an enormous need for action to take place in respect to pollution prevention, structural planning of new production plants and new pollution sites, preservation of the surrounding nature and an organisation of the regulatory authorities. In other words, the division of labour in the environmental field should be organised and meanwhile environmental improvements were made. The Ministry of Environmental Protection therefore soon became responsible for a fairly large administrative area - simply due to the fact that there was a profound political accept of this area and moreover a very obvious need for pollution preventing action.

4.2.2 Concern for the global effect of pollution

In the mid-80s, the international dimensions of pollution were a still growing issue. It was no longer sufficient to clean up in our "own backyard". It became

[53] At the time of establishment the agency was called National Agency of Environmental Protection.

clearer that effects from pollution in other parts of the world also have an impact on our health conditions (and vice versa). Thus, there was an increasing attention on the global characteristics of pollution.

This shift was stimulated by the UN report "Our Common Future" (1987) that introduced the concept of sustainable development implying that environmental policies should secure the same conditions for the next generations as we are provided with today. The report made it clear that in order to achieve a sustainable development, administrative and political decisions should incorporate environmental, economic and social concern. The report also included a plea that environmental concern need to be firmly anchored in sector policies in order to prevent the creation of environmental problems.

4.2.3 Denmark as an EU member state

Denmark became a member state of the European Community in 1973 – the year the EC adopted its first environmental action programme. The first legally binding instruments on environmental issues were adopted in 1975 (waste, air and water) and a general directorate on environment, DG Environment, was established the same year. A section covering the environment was included in the Treaty in 1987. The section covers aims and principles on the environmental area, it lays down EU authority to act on behalf of the member states, rules and procedures on the adoption of environmental legislation and the authority of the member states to implement more strict rules. Directive 85/337 on environmental impact assessment introduced a horizontal approach towards combating environmental degradation.

After 1987, the number of EU environmental legislation increased considerably. In the Treaty as amended by the Maastricht agreement, which entered into force in 1993, sustainable development of the environment is incorporated in article 2 (principles) and in article 6 it is stated that environmental considerations shall be integrated in each sector policy.

Through the years, Denmark has played an active role in EU on the field of environment. Both because Denmark has been one of the leading countries in Europe on the environmental field, but probably also because Denmark as a small member state would have little success in trying to dominate the "heavy" areas lead by Germany, France and England. The field of environment has therefore been a convenient tool for promoting Denmark in the EU. Denmark was one of the main initiators of the amendments of the Treaty in Maastricht in 1992.

The areas of Danish environmental regulation that are most dominated by EU regulation are water, air, waste and chemicals. For further information, please refer to chapter 3, section 3.3.1.

Since 1967 the EU has promoted the harmonisation of regulations on the area of chemicals based on interests for promoting the free movements of goods. Later on environmental considerations were included in the grounds for regulating the area. Most directives on chemicals are total harmonisation directives. The area of chemicals has therefore been largely influenced by EU regulation from the very beginning of Danish EU membership.

4.2.4 Action plans

Since the mid-80s the period was characterised by the elaboration of several overall action plans. This was not least stimulated by the "Our Common Future" report which did challenge authorities to be crucially aware of the time-horizon of decision-making in order to avoid solutions that only are beneficial to society within a short-time perspective. These plans are briefly presented below:

- The first action programme to reduce nitrogen, phosphorus and organic matter from agriculture, the so-called NPO action plan, was presented in 1985. It was replaced in 1987 by the more comprehensive Action Plan for the Aquatic Environment.

- The Pesticide Action Plan, 1986, aimed at reducing pesticide application.

- The Action Plan for Sustainable Agriculture, 1991.

- The Action plan for energy and transport greenhouse gas emissions, "Energy 2000". The purpose of the plan is to fulfil Denmark's international obligation under the Climate Change Convention and related EU-agreements.

The action plans would normally contain specific, often quantitative, time-bound, and measurable environmental targets. They also list specific initiatives that shall be carried out in order to achieve the objectives.

4.2.5 The dominant understanding

Overall it had become popular during this period to be concerned about the environment and therefore, the political parties fought about the "right" approach to environmental issues and pollution prevention. The environment kept its status as a highly important issue within the Danish society and there was a continuous focus on governmental attempts to make the environmental rules more rigorous.

Differences in understanding of the relationship between nature and human beings acted as the template for the Danish environmental debate. On the one hand environmental activists were frightened by the dark predictions and agitated for a need to act in pact with nature.

On the other hand, industry sometimes found itself held responsible for environmental impact from both significant and insignificant pollution in which it was difficult to prove or verify their emissions or lacking emission. However, due to the historically accepted commitment to the regulatory system as well as the general societal acceptance of the environmental concern, industry found itself in a situation where it felt obliged to obey environmental regulation both at the local and governmental level.

4.3 Prevention of environmental problems (1992-98)

With the adoption of a profoundly revised Environmental Protection Act in 1991, the Ministry of Environment and Energy changed the focus into initiatives based on cleaner technology. The wording of the new law was to prevent and combat pollution by way of the following:

- Limit the use and waste of natural resources and other resources
- Encourage the use of cleaner technology
- Encourage recycling and reduce problems connected to removal of waste.

Compared to the former environmental act, this law was strongly oriented towards pollution prevention. Lifecycle analyses and substitution of the use of non-renewable resources became important issues. The regulators tried to help industries and households in the processes to measure the consequences of production or consumption and seek for alternatives.

4.3.1 Effect on society

The new type of regulation presented in the new 1991 Environmental Protection Act made it possible for the single company or organisation to gain some value for their environmental investments instead of only regulatory compliance. Cleaner technology was an initiative that on the one hand could reduce the use of non-renewable resources and limit emissions, and on the other hand could result in technological progress. Therefore, many companies and organisations saw an advantage in the new law and began actively to take part in the process of improving the environmental conditions.

Industry definitely realised during this era that they had to deal with environmental issues one way or the other.

4.3.2 Local Agenda 21

Following the Rio 1992 Summit held by the UN, Denmark started to initiate Local Agenda 21 activities. The set-up was for every participating country to organise holistic environmental initiatives at the municipal level. In Denmark the municipalities were already quite familiar with environmental regulation and some of them saw it as a new opportunity to promote environmental concern in their local jurisdiction. Unfortunately, many municipalities had difficulties in lifting the obligation. During the following years, however, these municipalities could adopt some of the initiatives from the proactive municipalities with the result that many of the Danish municipalities now have a fairly high level of environmental concern integrated in their political strategies and daily work.

70% of Danish municipalities have currently elaborated Agenda 21 plans.

4.3.3 The political consumer

In this period environmental policy became a matter also of consumer behaviour; a phenomenon called the political consumer. This tendency was actually encouraged by the authorities via the introduction of various forms of green labelling. This aimed at making it easier for the consumer to choose products that are acceptable from an environmental and health point of view. This era also saw some very spectacular events that made *the political consumer* react strongly. A well-know example is Brent Spar:

The Shell company had worked closely with the British authorities to point out an environmentally acceptable way to eliminate Brent Spar – an oil rig in the North Sea. Despite Shells efforts, Greenpeace declared that Shell was dumping the oil rig in order to avoid costly investments needed to secure the environmental conditions.

In Denmark the Greenpeace wave was followed. Central actors in the environmental policy such as the Minister of Environment and the EU-Commissioner for environment all chose to believe Greenpeace. Ritt Bjerregaard, the then Danish environmental EU-Commissioner, said that it was a great victory for environment not to dump the Brent Spar. The Danish Minister of Environment and Energy argued that the Danish government would consider to boycott Shell as a supplier and moreover they proposed to their citizens to boycott Shell as well.

To the industry the event demonstrated the importance that environmental precaution for companies had reached. With one strike it became clear that insufficient environmental precaution could lead to closing down a business. Moreover, there were a lot of external environmental stakeholders who identified themselves as "the tongue of nature" and expected to be heard.
Another effect was the rise of a non-organised movement, the political concerned consumers, consisting of individual consumers, who would not accept the action from Shell and thus decided to boycott the company. The movement indicated a strong political attitude and a high level of environmental concern. This movement was characterised to consist of well-educated, fairly young citizens with a relatively high salary and a more or less leftwing political orientation[54].

4.3.4 Environmental standardisation

Besides the new awareness of the possible advantages of environmental concern and investments in new technology, the market itself set up methods to deal with the environmental issues in the market. Until then, many companies had tried to promote themselves as a green company or a producer of green products and this tendency had caused a considerable amount of problems due to the inconsistency in these statements. Quite often it was impossible to evaluate the statements and thus risky for a company to buy these products as "green" or environmentally friendly.

By the mid-1990s, a new tool was evolving in the form of environmental management systems and certifications of these. With the new standardised certification of environmental management systems, EMAS and ISO 14000, other aspects than governmental rule became crucial for the industry to relate to. Most of the Danish companies had an experience with certification of quality management (ISO 9000) and were therefore familiar with the underlying consequences of being certified but still only few enterprises have acquired a certification.

4.3.5 Integrated Product Policy

In 1996 the Danish EPA introduced a new strategy which set focus on the environmental impacts from products throughout their lifecycle. It was recognised that the future environmental improvements to achieve the sustainable

[54] Study made by Greens Analysis Institute for Børsen to profile the political consumer in Denmark based on interviews of 861 persons. 42% of the interviewed had used boycott of consumption product as a political tool to their resistance against the activities of the producer or country. Presented in Børsen 29-2-96.

development objectives had to involve the impacts from products as well as a stakeholder involvement.

The previous environmental efforts were based on approaches towards sources, medium and substances. The product oriented approach aims at continuous improvements in the environmental performance of products and services within a lifecycle context. The strategy also includes market development to promote production and marketing of cleaner products. At the initial stage the efforts was concentrated on the development of tools to analyse and assess the environmental impacts of products and development of a public green procurement policy. However, the product initiative is defined to include the three major elements: lifecycle perspective, market orientation and stakeholder involvement.

This has been introduced for three pilot areas: Textiles, electronics and transportation of goods. For these three areas, product panels were set up with relevant stakeholders for each field. An essential task for each of these panels, as well as any future panel, is to draft action plans and to define commercial and environmental goals for each product area. Specific instruments and initiatives relevant for each product area are defined.

4.3.6 Other initiatives

A number of initiatives of a general interest were introduced during this period. The initiatives relating to environmental factors in relation to health, are listed below:

- The Parliament adopts the Action Plan on Waste and Recycling, 1992.
- The Danish Oil Association signs an agreement with environmental authorities concerning a clean-up programme for contaminated soil at the petrol stations, 1992.
- The government launches the green tax reform, which – among other things – introduces and raises a number of green taxes on consumption, 1993.
- The Ministry of Environment and Energy presents a green paper on “Strategy for the Protection of the Groundwater”, 1993.
- The Parliament adopts a number of green taxes to reduce Danish emission of CO_2 and SO_2, 1995.
- Parliament revises the Environmental Protection Law, introducing green accounting in companies likely to have significant impact on the environment, 1995.
- The Minister of Environment and Energy launches a strategy on protection of groundwater, 1995.
- Parliament adopts a revision of the Act on Chemical Substances and Products to phase out the most harmful pesticides, 1995.
- The Minister of Environment and Energy presents a report to Parliament on future initiatives in the field of chemicals, 1997.

- As a follow-up to the 1997 chemical strategy, DEPA presents a list of some 100 undesirable substances, 1998.
- The government approves the second action plan for the aquatic environment, 1998.
- The government releases a new action plan on waste called Waste 21, 1998.

4.3.7 The dominant understanding

The environment continued to be a salient issue in the public as well as the political arena; peaking from time to time when particular events stirred the attention. It was no longer questioned whether the environment should be protected, but rather the level of protection and how to achieve the desired level of protection. The agenda probably shifted slightly from being rooted in health concern towards focusing on protection of the natural environment. Nature restoration, for instance, became a well-know concept.

The period also marked a profound interest as to the global environmental problems, in particular the climate change issue.

4.3.8 The influence of EU

The EU had a significant effect on Danish environmental policies and legislation through the 1980s and the beginning of the 1990s.

However, in 1996 the IPPC directive was adopted introducing an environmental permit system for so-called heavy polluting industries. The system largely corresponds to the Danish environmental permit system and has not led to considerable changes in Danish regulation. Furthermore, the Air Quality Framework directive was adopted in 1996 fixing a number of principles for future air quality values, and the Water Framework Directive is probably going to be adopted by the end of 2000. All directives introduce a horizontal approach towards combating environmental degradation.

Denmark takes a great interest in the environmental work in EU and under the international society as such. Denmark is to a large extent influenced by, and influences, the environmental policies, strategies and principles that are given birth in these forums. In 1992, EU adopted the 5th Environmental Action Programme. The programme, which serves as the basis of the EU environmental policy and the guide for its related actions, differs from previous programmes. As its title 'Towards Sustainability' implies, the programme sets longer term objectives and focuses on a more global approach. It thus corresponded fairly well with the Danish priorities during this period.

4.4 Summing up

Danish and international environmental policy has changed radically since 1960.

First, it would appear that the starting point for environmental policy in Denmark was a concern for the public health rather than nature protection. Since the mid-19th century, many Danes, in particular those living in the cities, have *sensed and felt* the problems on their own body in the form of poor air quality in cities, poor indoor climate, stench from human waste, reduced duration of life, etc. The health problems seem to have been an effective catalyst for environmental protection.

Second, the period since 1960 has been characterised by a significant increase in the political attention devoted to environmental and health issues; a development that parallels – albeit probably a bit delayed - the change in the public perception of pollution that has undergone a dramatic change from ignorance to high-level attention.

Third, during the last four decades the regulatory set-up has been established and refined. It began with the local health commissions and so far it has resulted in the establishment of the Ministry of Environment and Energy, in addition to environmental authorities at municipal and county level.

Fourth, the philosophy of regulation has changed. Once dilution was seen to suffice, but later – when the emissions were too massive to be absorbed by the recipients - the focus changed to cleaning. However, the cleaning approach was not unproblematic as if often resulted in a new waste problematic. This has spurred an interest in prevention of pollution via utilisation of cleaner technology and ultimately also of cleaner products.

In the table below, the development is summarised.

Table 4.1 Overview of main trends in Danish policy, etc. regarding environmental factors in relation to health

	Public perception of pollution and health	Political priority	Philosophy of regulation	Institutional and legal initiatives to combat pollution
1960-73	Pollution is in the beginning of the era neglected as a real problem During the end of era the impact of pollution on health and nature is recognised	Health and environment receives a low but increasing political priority Focus on avoidance of the most significant, local pollution	In the beginning: Regulation is not needed In the end of the period: Dilution in combination with clean-up of hot-spot pollution	Establishment of local Health Commissions and Hygiene Commissions Establishment of a Ministry for Environmental Protection
1973-92	Pollution is destructive for us and our nature The global effects of pollution is gaining attention	A significant higher priority is devoted to environmental policy, in particular since the mid 1980's The global effects of pollution is gaining attention	A systematic cleaning up and taxation of pollution is initiated	The first Danish Environmental Protection Act Elaboration of a complex set of environmental regulation
1992-98	Environmental concern is part of our daily life - whether we believe in it or not, we have to take environmental precautions	Environmental issues rank as among the most important political issues	Prevention, life-cycle analysis, integration of environmental concern into all aspects of societal decision-making	Strategic environmental planning, including the preparation of action plans outlining quantitative objectives

4.5 References

Brundtland, G.H. (1987): "*Our Common Future*", Report from the World Commission on Environment and Development, Oxford University Press, Oxford

Engberg, Jens (1999a): "*Det heles vel. Forureningsbekæmpelse i Danmark fra loven om sundhedsvedtægter i 1850´erne til miljøloven i 1974*". Københavns Kommune, Miljøkontrollen. (Summary in English - see below).

Engberg, Jens (1999b): For The Common Weal. The story of pollution control in Denmark from the 1850s to 1974, City of Copenhagen, Miljøkontrollen.

Jamison, A. et. al, (1990): "*The Making of the New Environmental Consciousness - A comparative Study of the Environmental Movements in Sweden, Denmark and the Netherlands*", Edinburgh University Press, Edinburgh.

Jensen, B (1996): "*Miljøproblemer og velfærd*" (Environmental problems and Welfare), Spektrum, Copenhagen.

Lex; C (fourthcoming): "*Aktør i et spind af miljøforståelser - hvordan en virksomhed påvirkes i sit valg af miljøhandling*" (Actor in net of environmental misunderstandings - how a company is influenced in its choice of environment handling), Copenhagen Business School, Copenhagen.

Lykkegaard, M (1994): "*Skærpet erstatningsansvar for miljøskader*" (Increased liability for environmental damages), Lov nr. 225 af 6-4-94, Advokatfirma Bill Andersen, Århus.

Mikkelsen (1965): "*Speech form the Annual Board Meeting*", Danish Conservation Society.

Ministry of Environment (1988): "*Redegørelse om mål og midler i miljøpolitikken 1989-94*" (Statement of targets and means in the environmental policy), Copenhagen.

Ministry of Environment and Energy (1992) " *Miljøindsatsen i 90'erne - sigtelinier, principper, hovedindsatsområde*" (Environmental perfomances in the 90es, outline, principles and main areas) Copenhagen.

DEPA (1991) "*Orientering om ny miljøbeskyttelseslov*" (Information about the new law on environmental protection), orientering fra Miljøstyrelsen, nr. 6.

Moe, Mogens (1997): "*Miljøret*" (Environmental Law).

Pagh, Peter (1996): "*EU miljøret*" (EC Environmental Law).

5 Air

This chapter describes the environmental factors related to air pollution, and the sources, ambient levels, human exposure and health impacts of that pollution. Danish air quality legislation and regulation together with interna-tional protocols and EU-directives are summarised along with the sectoral and institutional framework for meeting the national and international require-ments for air quality management.

An overview of EU air quality limit values is included as an annex to this chapter. Danish principles for derivation of health-based air quality criteria are described in Appendix 1, along with a table of Danish permitting criteria (C-values) for 450 substances emitted by industry.

The issue concerning potential health effects of climate change is beyond the scope of this report. The chemical induced depletion of the stratospheric ozone layer is dealt with in Chapter 10, Chemicals.

5.1 Human exposure to environmental factors

5.1.1 Environmental factors

Air is the medium humans breathe, and in which we live, travel, and work. A clean atmospheric environment is essential to healthy living conditions, safe workplaces and protection of outdoor environments. Air is the transport medium for distribution of gases and particles in nature. It also transports and disperses a wide range of man-made pollutants.

The atmospheric environment receives emissions of pollutant gases and particles from a wide range of human activities. Power generation, industry and transportation are the activities with the largest share of emissions. Agricultural, commercial and domestic activities also contribute. Combustion of fossil fuels is the main source for pollutant emissions in all of these sectors. Production processes, waste incineration, leakage and evaporation of volatile chemicals and solvents, product use, and dust generated by vehicle traffic, construction and material handling are other major sources.

Air pollutants released to the atmosphere are dispersed by the wind, reducing concentration with distance from the source. However, the wind also carries pollutants throughout the country, and across the borders, influencing air quality over large areas. Some of the primary pollutants are transformed in the atmosphere into new physical or chemical forms, or into secondary pollutants. The air in Denmark is also significantly affected by long-range transport of pollutants from other parts of Europe.

Essentially all of the population is exposed to primary pollutants, because the emissions are so large, or because they are emitted from so many sources. Some of the most well known air pollutants with respect to health impacts are summarised in table 5.1.

Table 5.1 Summary of the sources and potential health impacts of the most important air pollutants in Denmark.

Environmental factor	Main Sources	Potential Health Impact
Particulate Matter (PM) A mixture of solid particles and liquid droplets.	Course particles: Road dust, grinding, agricultural operations. Fine particles: Vehicle exhaust, power plants, industry, incineration	Increased daily mortality, increased hospital respiratory admissions, chest pain, aggravated coughing, increased bronchitis in children
Nitrogen dioxide (NO_2) A reddish-brown gas that is a strong oxidant and highly soluble in water.	Vehicle exhaust, power plants, industrial and domestic combustion. NO_2 is part of NO_X.	Decreases in pulmonary function, exaggerated response to allergens in asthmatics
Ozone (O_3) A colourless or bluish gas and a very strong oxidant.	Formed in the atmosphere from nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of heat and sunlight.	Eye, nose and throat irritation, impairment of pulmonary function, chest discomfort, cough, headache, increased respiratory hospital admissions, exacerbation of asthma and other respiratory symptoms
Sulphur dioxide (SO_2) An irritating, reactive and water-soluble gas	Combustion of fuels containing sulphur, such as coal, oil, and diesel fuel, and industrial processes using sulphur compounds.	Decreased lung function, increased hospital emergency admissions for total respiratory causes, increased mortality.
Carbon monoxide (CO) An odourless, tasteless, colourless gas.	Vehicle exhaust.	Reduced oxygen-carrying capacity of blood. At high exposure levels toxic effects on brain, heart, exercising muscle and developing foetus, increased cardiovascular mortality (heart attacks)
Polycyclic aromatic hydrocarbons (PAH) Organic substances deposited on particulate matter.	Vehicle exhaust, especially diesel. BaP is the most well-known of the PAH substances	Human carcinogen.
Volatile Organic Compounds (VOC) The most critical VOCs are:	Vehicle exhaust, evaporation of fuels, oils and solvents.	The health effects of VOCs vary considerably from compound to compound.
• **Benzene**	Vehicle exhaust, fuel evaporation, glues and solvents.	Known human carcinogen.
• **1,3-Butadiene**	Vehicle exhaust, manufacture of plastics and synthetic rubber.	Probable human carcinogen
• **Aldehydes** (formaldehyde, acetaldehyde, acrolein)	Vehicle exhaust, and formed in the atmosphere by photochemical reactions.	Irritation of upper respiratory tract and eyes. Formaldehyde and acetaldehyde are probable human carcinogens.
Dioxins	Combustion of organic material containing chlorine (e.g. burning of household waste, illegal burning of waste in private woodburning stoves etc.) and some industrial processes involving chlorine as well as remelting of steel and aluminium scrap.	Anticipated to be a carcinogen Chloracne Weakens the immune system and may cause reproductive damage. Disruption of endocrine system.
Lead (Pb) Hazardous heavy metal occurring in particulate matter in the air.	Vehicles using leaded petrol (lead is no longer added to motor fuels in Denmark), waste incineration, coal combustion.	Known neurotoxin. (Lead deposition on soil and surfaces more important in relation to human exposure than direct inhalation)

Numerous other pollutants are emitted to the air, or are present in the background air pollution transported to Denmark from other countries, but at levels considered to be of minor importance in relation to health.

People living near industries can be exposed to a wide variety of compounds released from production processes and material handling. Denmark regulates the emission of about 450 compounds from industries, for protection of health and the environment, which helps limit the number of people exposed to them. Typical high-volume hazardous substances used and/or emitted by Danish industries include toluene, xylene, 1,1,1-trichlorethane, trichlorethylene, ammonia, and formaldehyde (DEPA, 1995). There are large emissions of VOCs emitted from various other solvents, adhesives and coatings. It should be noted that not all of the industrial chemicals are regulated because of health concern. Many solvents in, e.g. the paint industry are regulated with the aim of protecting the population from (mal)odourous emissions as many chemicals have an odour threshold below the health based guidance values. The regulatory process for approval of enterprises using or emitting listed chemicals is outlined in section 0.

Some persistent organic pollutants (POP) are transported through the air. Some are ”semi-volatile”, meaning that they readily evaporate and condense at typical ambient temperatures. This behaviour causes POPs to evaporate from one location when warmed, and condense again when cooled, leading to a gradual transport and accumulation in cooler regions, such as the arctic.

Dioxins are a class of highly toxic organic compounds that are formed during combustion of organic material containing chlorine, especially polyvinyl chloride plastic (PVC), and some industrial processes involving chlorine as well as remelting of steel and aluminium scrap. Dioxins can be produced from incineration of household waste, but release is minimised by waste sorting, carefully controlled high-temperature combustion, and pollution control measures. Small farm boilers and private woodburning stoves are also possible dioxin sources because of incomplete combustion and possible illegal burning of waste (impregnated or painted wood, cardboard, milk cartons etc.).

5.1.2 Sources of pollutants

Ambient concentrations of air pollutants cannot be directly controlled, but the sources of emissions of pollutants can be controlled by a wide range of technical and administrative means. Danish air quality is partly the result of long range transboundary air pollution from emissions, which implies that it depends on environmental regulation and management of sources in other countries. This makes EU-directives and international protocols and cooperation a significant part of the management of Denmark’s atmospheric environment.

Heat and power production

Heat and power production in Denmark primarily uses coal and natural gas. The release of emissions from heat and power production is from high stacks, which are designed to assure that limit values are not exceeded at ground level.

The primary pollutants released during combustion are carbon dioxide (CO_2), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM) and volatile organic compounds (VOC). CO_2 is non-toxic in ambient concentrations, but is a greenhouse gas significant for climate change. VOCs are a mixture of organic compounds, with varying health impacts. Particulate matter varies in size and chemical composition. The makeup of combustion PM and VOCs, and the associated health impacts, varies significantly among the different forms of combustion. Fuel contaminants or additives give rise to additional pollutants, such as sulphur dioxide (SO_2), acids (especially HCL), heavy metals (Hg and others) and dioxins.

Industrial sources
Combustion for industrial heat and power utilises coal, oil and natural gas. Industrial process pollutants include acid gases, PM, VOCs, a variety of different industrial chemicals, heavy metals, POPs and microbiological pollutants. Diffuse (fugitive) emissions of PM also occur from material storage and handling.

Transportation sources
Transportation emissions include exhaust from motor vehicles, diesel trains, ships and ferries, and aircraft. There is also evaporation of VOCs from vehicles and fuel distribution, and PM from road dust and tyre wear. Pollutants include NO_X, CO, SO_2, PM, VOCs and heavy metals. Denmark's rail networks are largely electrified, which shifts emissions to power plants where greater emission control is possible.

Domestic, commercial and public sources
Domestic, commercial and service sector emissions include heating and cooking (oil and natural gas), architectural coatings (paint), and use of consumer and office products. Emissions include a wide range of VOCs from cooking, the use of glues, coatings and other products containing solvents, in addition to the primary pollutants from combustion.

Waste
Emissions from household waste incineration include NO_X, SO_2, PM, VOCs, dioxin, and heavy metals. There are emissions of VOCs and microbiological pollutants from wastewater treatment plants.

Agriculture
The main emission from agricultural emissions is PM from field operations. Agricultural heat and power, off-road vehicles and use of pesticides also generate emissions. Burning of fields has been prohibited for more than 10 years, except under certain circumstances. Significant amounts of ammonia are released from animal manure.

Secondary pollutants
Pollutants that are formed in the atmosphere rather than emitted by a source are known as secondary pollutants. Tropospheric ozone is formed in atmosphere as secondary pollutant by sunlight acting on precursors NO_X and VOCs. Most ozone in Denmark is imported by long-range transport from other countries. Small aerosol particles can also form in the atmosphere from other pollutants, especially sulphates and nitrates.

National total emissions
Table 5.2 shows the annual emissions of four major pollutants in Denmark, for 1998, by CORINAIR sector. CORINAIR is the emission inventory system established for reporting of national emissions to the EU and the EEA. The CORINAIR system includes the emission source classification scheme known as "SNAP" which is based on 11 major anthropogenic source sectors, as shown in Table 5.2, plus natural sources.

Table 5.2 Denmark's 1998 national total anthropogenic emissions of primary pollutants by CORINAIR sector (see text), in tons/year and percent of total national emissions. Based on CORINAIR data. Source: NERI.

CORINAIR Sector	SO_2		NO_x		CO		NMVOC[i]	
01 Energy	55,180	72%	73,428	32%	13,440	2%	1,681	1%
02 Non-industrial combustion	3,528	5%	6,316	3%	158,325	27%	9,582	7%
03 Industrial combustion	9,923	13%	15,440	7%	7,714	1%	802	1%
04 Production processes	1,441	2%	348	0%			5,061	4%
05 Extraction and distribution of fossil fuels					31,290	5%	5,523	4%
06 Solvent and other product use							38,864	27%
07 Road transport	1,964	3%	76,492	33%	305,716	52%	52,058	36%
08 Other mobile sources and machinery	4,799	6%	57,393	25%	69,740	12%	13,590	9%
09 Waste treatment and disposal	70	0%	2,197	1%	1,415	0%	615	0%
10 Agriculture							1,222	1%
11 Other sources and sinks							14,095	10%
Total	76,904	100%	231,614	100%	587,639	100%	143,094	100%

Concerning other pollutants it should be mentioned that a new investigation of dioxin emissions in Denmark has been performed based on measurements of emission sources. The total dioxin emission to air in Denmark is estimated to 95 g per year as best average (DEPA 2000).

5.1.3 Observed levels of pollutants

Air pollution in Denmark is monitored through a combination of measurement programmes and modelling. The fourth Danish Air Quality Monitoring Programme (LMP-IV) was started in January 2000 (NERI 2000). The programme comprises an urban monitoring network with stations in four Danish cities. The results are used for assessment of the air pollution in urban areas. The programme is carried out in a cooperation between the Danish Environmental Protection Agency, the National Environmental Research Institute (NERI), the Greater Copenhagen Air Monitoring Unit and the municipal authorities in the cities of Aarhus, Odense and Aalborg. The results are currently published in quarterly reports in Danish and they are summarised in annual reports in English. The monitoring programme fulfils the obligations contained in the new EU framework directive on air quality and the daughter directives on SO_2, NO_2, particulate matter, lead, benzene, carbon monoxide and ozone. The programme also includes application of model calculations at street level.

Table 5.3 summarises recent observed levels of key air pollutants from the Danish monitoring programmes. The table also provides corresponding EU limit values, which are discussed in section 5.2.1.

TABLE 5.3 OBSERVED AMBIENT CONCENTRATIONS OF AIR POLLUTANTS FOR URBAN TRAFFIC AND RURAL MONITORING SITES COMPARED EU AND DANISH LIMIT VALUES. 1998 DATA IN µG/M^3 FROM KEMP AND PALMGREN (1999) EXCEPT AS NOTED. CONCENTRATIONS THAT ARE ABOVE LIMIT VALUES ARE SHOWN IN BOLD. LIMIT VALUES ARE THE NEW EU LIMIT VALUES, EXCEPT AS NOTED. THE YEARS IN WHICH NEW LIMIT VALUES MUST BE COMPLIED WITH ARE GIVEN IN PARENTHESES.

Pollutant	Averaging period and calendar year statistic	Urban traffic sites µg/m^3	Rural µg/m^3	EU limit value µg/m^3
Sulphur dioxide (SO_2)	1 hour, 25th highest	33–48	22	350 (2005)
	24 hours, 4th highest	11–17	14	125 (2005)
	1 year, average (vegetation)	2.2–4.4	1.5	20 (2001)
Nitrogen dioxide (NO_2)	1 hour, 19th highest	102–117	54-61	200 (2010)
	1 year, average (vegetation)	32–**43**	11	30 (2001)
	1 year, average	32–**43**	11	40 (2010)
PM_{10}	24 hours, 36th highest	(appr. 43)[a]		50 (2005)
	24 hours, 8th highest	(appr. **65**)[a]		50 (2010)
	1 year, average	(36)[a]		50 (2005) 20 (2010)
Carbon monoxide (CO)	8 hours, maximum	4,970–5,339		10,000 (2005)
Benzene	1 year, average	4.8–**7.0**		5 (2010)
Lead (Pb)	1 year, average	0.015–0.020		0.5 (2010)
Ozone (O_3)	1 hour, maximum	119	145–156	200[b]
	8 hour[c], 21st highest day	(not calculated)		120[d]
	8 hour[e], maximum	**111–123**	92	110[f]
	1 year, average	48–50	33	

[a] Partial year measurement (1/3 year) at only one station.
[b] Threshold value (vegetation).
[c] Running 8-hour average, highest each day.
[d] Proposed EU limit value.
[e] Non-overlapping 8-hour averages
[f] Threshold value (human health)

The 1999 EU daughter directive also requires $PM_{2.5}$ (particulate matter less than 2.5 µm in diameter) to be measured and reported for representative locations, although limit values are not establish. Danish $PM_{2.5}$ measurements are being started in 2000 as part of the revised national air quality monitoring programme (LMP-IV).

Trends
The level of SO_2 in Denmark has been decreasing since it peaked in about 1984. The reduction is most evident for average values that are determined by the contributions from local sources. Average SO_2 concentrations have been reduced by almost a factor of five. Short-term statistics, such as the 25th highest hour statistic, are more influenced by long-range transport episodes (NERI 1999).

Average NO_2 levels have been decreasing slightly since peaking in the late 1980's and early 1990's. The short-term statistics have been fairly constant after a weak maximum in the late 1980's. The 1998 annual average NO_2 levels at a traffic site in Copenhagen is slightly over the new EU limit value that must be met by 2005, while the short term NO_2 statistic (19^{th} highest hour) is well under the EU limit value.

Levels of total particulate matter (TSP) have been declining gradually since the late 1980's. TSP has been measured in Denmark since the 1970's, but PM_{10} measurements began in 1998. Early results from PM_{10} monitoring indicate that PM_{10} levels are close to or slightly over the new EU limit values.

Benzene and CO concentrations have been falling in Copenhagen since measurements began in 1994, except for variations due to meteorological variability. This decline reflects the increasing number of cars with three-way catalysts. Benzene has fallen more sharply than CO due to the reduction of the benzene content in petrol from about 3.5% in 1995 to approx. 1% in 1998 (NERI, 1999).

Ozone levels show a declining trend since measurements began in 1992, although with considerable variation from year to year.

5.1.4 Human exposure

The total daily exposure of an individual to air pollution is the sum of the separate contacts to air pollution experienced by that individual as he/she passes through a series of environments during the course of the day: at home, while commuting, in the streets, etc. Exposures in each of these environments can be estimated as the product of the concentration of the pollutant and the time spent in the environment.

An ideal characterisation of the distribution of human exposures would be based on direct measurements of each pollutant concentration in the breathing zone of each member of a representative cross section of the population of interest. Such a programme is impractical if not technically impossible. Instead, ambient air quality measurements at central, fixed, air monitoring sites are widely used as substitute indicators of population exposures.

Measurement of daily average concentrations of a pollutant at a single, fixed-site outdoor monitoring point provides only a rough indicator of actual exposure, but these are generally the only widely available quantitative data that can be related to exposures. Some pollutants – for example ozone and fine particles ($PM_{2.5}$) – are comparatively evenly distributed across large areas and monitoring them at a limited number of sites may provide an adequate indication of concentrations over wide regions. On the other hand, concentrations of pollutants from traffic decline rapidly as one moves away from busy roads. Similarly, many industrial pollutants are localised near the industries that emit them.

Indoor exposures may be very different from that outdoors. Air pollutants emitted into outdoor air can be attenuated during infiltration into indoor air. This attenuation can be expected to be minimal for all pollutants of outdoor origin when barriers such as windows and doors are open or absent. In contrast, attenuation can be very large for tightly sealed buildings during times of maximal heating or cooling needs.

For relatively non-reactive gases like CO, or non-reactive fine particulate matter such as sulphate, indoor concentrations are usually near outdoor levels in homes without indoor sources. However, indoor concentrations can be much higher than outdoor concentrations when there are sources such as burning cigarettes and open flames used for cooking or space heating. Chemically reactive gases, such as O3 and SO2 react with interior surfaces, so indoor concentration are typically much lower than outdoor levels.

Concentrations of pollutants generated by motor vehicles may be significantly higher inside motor vehicles than average outdoor levels, and thus the motor car may itself be a significant microenvironment.

The levels of air pollution generally increase with increasing size of city or increasing traffic intensity. Levels generally decline going from city centre towards the suburbs and out into the countryside. About 1.8 million people in Denmark live in large urban areas, including about 1.5 million in the metropolitan Copenhagen area. Residents living along busy streets will be particularly exposed to pollutants emitted by traffic.

Lead and PAH are air pollutants that can gain access to humans through indirect transport routes. These other exposure routes dominate over inhalation exposure for these pollutants. Particles in exhaust containing lead or PAH deposited on terrestrial surfaces can be ingested; either directly from soil in play yards, or after being carried indoors as a component of house dust (especially for small children). Furthermore, particulate lead and PAH deposited on plants or agricultural fields can be retained in food products and added to body burdens. Dioxins are transported through the air, but the predominant exposure to dioxins is through the ingestion of food, especially from fish and fatty animal products in which dioxins tend to accumulate.

5.1.5 Health significance of air pollution

Inhalation of air pollutants is essentially unavoidable. Pollutants emitted into the atmosphere affect people when they are outdoors. Pollutants also infiltrate into homes, workplaces and vehicles, adding to pollutants emitted within those spaces, and contributing to peoples' exposure around the clock.

It is very difficult to give precise quantitative information about the effects of air pollution on the Danish population because very little research has been done on this issue in Denmark. In other countries, especially in North America, knowledge about adverse health effects of air pollution has increased dramatically during the past ten years.

It is now generally agreed (from the majority of reviews and WHO assessments made in this field) that air pollution at the present level in Western Europe is expected to be associated with considerable adverse health effects in the human population. Air pollution has been found to be associated with increased morbidity and mortality determined by a variety of effects parameters such as the mortality rate, hospital admissions, occurrence of respiratory symptoms in the population, use of asthma medicine, decline in lung function, days absent from work or school, etc.

It is recognised that specific groups of the population are at risk, and especially in situations with high exposure or during episodes with increased levels of the air pollutants. From various studies the risk groups have been identified as people suffering from chronic respiratory diseases, people with cardiovascular diseases, elderly people, infants and children. Taken together, these groups make up quite a large percentage of the population. It should be noted that even at today's relatively low pollution levels – compared to former times –effects are expected to occur and primarily among the above mentio-ned risk groups.

An interministerial task group was established in 1998 by the Ministry of Environment and Energy and the National Health Agency to assess the health implication of air pollution in Denmark, based on present knowledge, with special emphasis on the consequences of implementation of new and proposed EU limit values. Based on the evaluations of this task group, particles and ozone are considered to be the most critical air pollutants in Denmark in relation to health effects.

Particles

In recent years, increased focus has been placed on the adverse health effects of particles. Particles may be measured in different size fractions. The fine particle fraction $PM_{2.5}$ (particle diameter less than 2.5 microns) has been found to be the particle fraction most closely associated with adverse health effects in epidemiological studies. Table 5.4 and Table 5.5 show the dose-response relationships between particles and health effects from short-term and long-term exposure that were established in the WHO (1996) update of the air quality criteria for particulate matter.

Table 5.4 Associations between 3 days periods with mean PM_{10} concentration of 50 and 100 g/m^3 and the increase in subjects (in a population of 1 million) experiencing health effects (WHO 1996)

Health effect indicator	**Number of subjects affected by a three-day episode of PM_{10} at:**	
	50 g/m^3	100 g/m^3
Mortality	4	8
Respiratory hospital admissions	3	6
Person-days of bronchodilator use	4863	10514
Persons-days of symptom exacerbation	5185	11267

Table 5.5 Summary of health response associations per 10 g/m^3 average long-term concentration of $PM_{2.5}$ (modified from WHO 1996).

Health indicator	**Response association per 10 g/m^3 average long term concentration of $PM_{2.5}$**
Increase in annual mortality, general population	+ 7-14 %

Health indicator	Response association per 10 g/m^3 average long term concentration of $PM_{2.5}$
Increase in persons experiencing bronchitis symptoms, general population	+ 34 %
Number of additional children with bronchitis symptoms per year per 200,000 children	+ 3350
Number of additional children with lung function below 85% of normal predicted function per 200,000 children	+ 4000

The expert group of the WHO stated that no threshold could be determined for health effects associated with particulate matter. Comparing the dose-response associations given by the WHO with the present levels of particulates in Danish cities, it has been estimated that a 1/3-reduction of the annual average particle level in Danish cities (i.e. a reduction of about 15 μg/m^3 TSP (total suspended particulates) corresponding to approximately 5 μg/m^3 $PM_{2.5}$) would imply a decrease in annual mortality of about 400 deaths among 1 million people and a decrease of about 1,700 children suffering from bronchitis (MEM 2000a).

Ozone

Ozone is a strong oxidant causing respiratory symptoms, decline in lung function, increased airway responsiveness to irritants, and airway inflammation. Epidemiological studies have shown a relationship between ozone levels and respiratory symptom exacerbation among healthy children, adults and asthmatics corresponding to a 2.5% increase per 10 g/m^3 increase in the 8-hour average ozone level, together with a 2 % increase in hospital admissions due to respiratory conditions (WHO 1994).
Effects of ozone have been found down to levels below 100 g/m^3, but no exact lower threshold for adverse effects from ozone exposure has been identified. In Denmark, the 98-percentile for ozone levels is at about 100 g/m^3 and thus health effects from ozone exposure are to be expected in Denmark. Children, infants, elderly, ill and generally weakened persons are considered at special risk for adverse effects from ozone exposure. People spending much time outdoors (e.g. children), and people physically active outdoors are the most heavily exposed groups (MEM 2000b).

Dioxins

The emission of dioxins and dioxin-like PCBs is considered a problem in Denmark. Dioxins originate mainly from incineration and enter into the food chain after deposition on soil, crops, and in water. Recently (1999) WHO has set a health based tolerable daily intake value of 1-4 picogrammes TEQ (TCDD toxic equivalent) per kg bodyweight. In this year (2000) the Scientific Committee on Food has followed this up in the EU with a temporary value for tolerable weekly intake of 7 picogrammes TEQ per kg bodyweight. In the WHO evaluation it was stated that certain subtle effects may be occurring in some sections of the general populations of industrialised countries at current daily intake levels of 2-6 TEQ per kg bodyweight. In Denmark the Danish Veterinary and Food Administration has estimated an average daily human exposure of about 5 picogrammes TEQ per kg body-weight, i.e. a level above the tolerable levels given by the WHO and the Scientific Committee on Food. However, for the time being it is not clear whether or to which extent such an exposure level contribute to effects in the Danish population.

5.2 Level of protection

For unavoidable emissions to the air of harmful substances it is an overall aim that these must be handled in a way that human beings are not exposed to health hazards or nuisances, and animal and plant life are not harmed. With respect to health considerations this covers both protection from effects by direct inhalation and indirect effects from transmission of air pollutants to for example drinking water, soil and foodstuffs. The human protection also includes prevention against nuisances in the form of odours and dust. Furthermore, ecological considerations cover both direct effects on animal and plant life, and protection of the atmosphere against dangers, such as changes in the ozone layer.
The level of protection is primarily determined by use of health based guidance values or quality criteria, as well as the use of emission limits. The air quality criteria set by the Danish EPA are considered to represent a high level of protection. Further details on the scientific method for elaboration air quality criteria are given in Appendix 1.

5.2.1 Air quality norms

Extensive reviews of heath impacts of air pollution have been carried out recently by WHO (2000), based on methodologies established by WHO. The resulting WHO guidelines for air quality have formed the basis of the new EU daughter directives under the Framework Directive on Air Quality Management. Danish specialists have participated in the technical working groups preparing initial drafts for the directives.

The new EU daughter directives contain binding limit values for the member states, along with details on measurement and reporting requirements. These limit values are to be implemented in the national laws of the member states, including Denmark. Deadlines are set, for example 2005 or 2010, by which the limit values must be met.

The EU framework directive for air quality management requires preparation of daughter directives for the pollutants governed by existing EU ambient air quality directives, sulphur dioxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), lead and ozone, plus the additional pollutants benzene, carbon monoxide, poly-aromatic hydrocarbons, cadmium, arsenic, nickel and mercury. A summary of EU ambient air quality limit values for the protection of human health is given in Appendix 3. The numerous other hazardous chemicals that are emitted into the air by industries and other sources will not have EU limit values in the fore-seeable future. To regulate these industrial chemicals, the Danish EPA has established principles for determination of health based guidance values/ air quality criteria for specific chemical substances. These values are used to calculate the allowable emissions of chemical substances from industry and to calculate release heights (see Appendix 1).

The Danish principles for determination of health based guidance values for chemical substances involves review of the scientific research done on the possible harmful effects of a substance, in both epidemiological experiments and experiments with animals. From these data, the guidance value/quality criteria is set at a level considered not to cause any adverse effects in the population.

When the guidance values have been determined, they are used to derive specific statistical thresholds for practical regulatory use. These thresholds of pollutant concentration in the ambient air are known in Denmark as C-values (contribution values). A C-value is a limit value corresponding to a 99^{th} percentile statistic of measured hourly concentrations. This is a level that must not be exceeded more than about seven hours a month, or 1% of the time. The relationship between the health-based guidance value and the C-value depends on whether the health effect is acute (short-term) or chronic (long-term), and the uncertainty of the underlying data. The C-value is considered to reflect a high level of protection of human health, as the C-value in most cases is set equal to the health based guidance value.

After establishing acceptable emission amounts and concentrations from an industry, an atmospheric dispersion model is then used to determine the minimum release height (stack height) for the emissions. The model calculates hour by hour ambient concentrations of a pollutant over a year, based on emission rates and hour by hour meteorological data. The 99^{th} percentile statistic derived by the model is compared to the C-value for the pollutant. If the C-value is exceeded, the height of emission must be raised until the C-value is not exceeded.

A problem with limit values arises for air pollutants that do not have a lower threshold for health effects. Fine particulate matter is now recognised as a major health hazard in Danish cities. WHO (2000) was unable to identify a lower threshold for health effects of fine particulate matter (PM_{10} and $PM_{2.5}$). Nonetheless, the first EU daughter directive specifies short-term and long-term limit values for PM_{10} and permits the short-term limit value to be exceeded on up to 35 days per year. Present levels of PM_{10} in urban areas in Denmark appear to be close to or somewhat over the new EU limit values. As shown in the previous section, a 1/3 reduction of annual $PM_{2.5}$ levels in Danish urban areas could be expected to result in about 400 fewer deaths per one million population *per year* (MEM 2000).

Ozone is another air pollutant without a lower threshold for health effects and a serious health hazard in Denmark. Clear and significant dose-response relations have been found in international studies for ozone concentrations between 40 and 200 $\mu g/m^3$. Nonetheless, WHO (2000) has established a guideline value of 120 $\mu g/m^3$ for 8-hour average concentrations, and this value is proposed to be used in a new EU daughter directive on ozone. As previous-ly mentioned, ozone levels above the 100 $\mu g/m^3$ level occur in Denmark and thus health effects from ozone exposure can be expected in Denmark.

For both fine particulate matter and ozone, the present level of regulatory protection is rather weak. The present levels of these pollutants, and the present limit values, imply tolerance of significant health impacts - even deaths - in the population. This is in stark contrast to the health-based regulation of water and soil pollution in Denmark, where any effect in the population is totally unacceptable. The outlook for fine particulate matter and ozone is not promising either. Both pollutants are very difficult to control, and their levels in Denmark depend significantly on transboundary air pollution transport. However, reduction measures for local sources of particulate matter may affect local population exposure to a great extent.

For dioxins it is similarly difficult to evaluate the degree of protection with regard to Danish dioxin emissions, since it is difficult to assess the contribution from Danish dioxin emissions to the current exposure of the Danish population. Nonetheless, a higher degree of protection and emission reductions are warranted as average exposure of the population is estimated to exceed the tolerable intake values of the WHO and the Scientific Committee of Food in the EU.

5.3 Regulation and strategy

Objectives and principles

International and EU co-operation and objectives
As mentioned above, ambient air pollution is transboundary. Long-distance transport of pollutants means that Danish air quality is partly the result of environmental regulation and management of sources in other countries. This makes international co-operation a significant part of the management of Denmark's atmospheric environment. The major part of the national efforts in combating air pollution is done in EU and UN, including UN/ECE and UNEP.

EU legislation in this field is principally aimed at cutting emissions from industrial activities and road vehicles. Where transport is concerned, the strategy is:

- to reduce polluting emissions (catalytic converter, roadworthiness test);
- to reduce the fuel consumption of private cars (in collaboration with car manufacturers);
- to promote clean vehicles (tax incentives).

The EU legislation on the transport area concentrates on cars. Measures to combat air emissions from trucks, railways, aeroplanes and ships have been less intense and less systematic[55]. Measures to reduce air emissions from cars have, since the early 1980's, been prepared by the Commission's Auto/Oil Programmes I and II.

There are several directives aiming at reducing emissions of air pollutants from industry. There are directives on emission limit values on combustion plants and on industrial installations. The IPPC-directive (96/61) is expected to result in a reduction of pollution, including air pollution, from heavy industries.

Air quality standards are advocated by Dir. 96/92/EC of 27 September 1996 on ambient air quality assessment and management (Air Quality Framework Directive) and by the subject of proposals of daughter directives under this Directive. The first daughter directive (1999/30/EC of 22 April 1999) relating to limit values for sulphur dioxide, oxides of nitrogen and nitrogen dioxide, particulate matters and lead in ambient air was adopted in 1999[56].

The major goals of the air quality directives are to provide a high level of protection for public health throughout the European Union, and to set ambient air quality limit values designed to protect the environment. The limit values are derived using the latest update of the WHO Air Quality Guidelines for Europe as a guide for the specific values.

---

[55] Transport by air is mainly regulated through International Civil Aviation Organization (ICAO). Maritime transport is mainly regulated through International Maritime Organization (IMO). Denmark strives to live up to any requirements laid down by these two organ isations.

[56] In the early 1980´s, the Community adopted three directives, with air quality standards for four pollutants: sulphur dioxide, suspended particulates, lead and nitrogen dioxide. The daugther directive aims at progressively replacing three air quality directives from the 1980's.

The work and the objectives under the *UN/ECE* have primarily been linked to the 1979 Convention on Long-range Transboundary Air Pollution. The Convention was the first internationally legally binding instrument to deal with problems of air pollution on a broad regional basis. It was signed in 1979 and entered into force in 1983. It has created the essential framework for controlling and reducing the damage to human health and the environment of transboundary air pollution. Since its entry into force the Convention has been extended by eight protocols. The Community is a Party to the Convention and to some of its protocols.

Objectives and agreements concerning substances that deplete the ozone layer are commented in chapter 10 on chemicals.

National objectives and principles
Concrete Danish initiatives to reduce air pollution are very much based on UN/ECE and EU requirements for the reduction of certain pollutants and on air quality, and national objectives concerning air pollution related environmental problems such as acidification and eutrophication. The Danish strategy for air pollution is to fully implement the EU directives and UN agreements, and to work through EU and UN to lower the limit values and strengthen the provisions of the directives and the agreements.

The Danish efforts in reducing CO_2 emissions are based on the actions plans Energy 2000 (1990), Energy 21 (1996), Transport Action Plan (1990), Traffic 2005 (1993) and the Danish Government's Action Plan to Reduce the CO_2 Emissions of Transport (1995). Regulation is e.g. based on quota legislation.

The protection of air quality is based on e.g. legislation on fuel quality; legislation on sulphur taxes on fuel; quota legislation on limiting sulphur dioxides and nitrogen oxides from the electricity sector; legislation on catalysts on new cars.

Table 5.6 Danish objectives on air pollution

Danish objectives on air pollution
Reduction in the emissions of SO_2, NO_X, NH_3 and VOCs by 2010 corresponding to a 50% reduction of the areas where the critical load for acidification is exceded compared to 1990 (Corresponding to following 2010 emission ceilings for Denmark: SO_2: 55,000 tons per year, NO_x: 127,000 tons, VOC: 85,000 tons, NH_3: 69,000 tons).
Reduction of 80% of SO_2 emissions in 2000 compared to the level in 1980.
Reduction of 30% of VOC emissions in 1999 compared to the level of 1985.
Reduction of 30% of NO_x emissions in 1998 compared to the level of 1986.

The NO_x objective has nearly been fulfilled; the reduction in 1998 compared to the level of 1986 was 28.5%.

5.3.1 Environmental objectives of industry

The industry sector, together with power generation, is a main contributor to the air pollution and is therefore in focus in general health, nature and environment policy efforts. The provisions of the Environmental Protection Act and Guidelines on Industrial Air Pollution Control regarding individual environmental regulation of enterprises, including the approval scheme[57] for the approximately 7,000 heavy polluters in Denmark, have proven an effective instrument for reducing the local environmental and health impact of industry. In recent years, direct legislative regulation of the sector has increasingly been supplemented by economic management tools and other tools such as environment labels, voluntary agreements and energy and environment management. The main objective of the Danish work concerning industry is to reduce air pollution as much as possible by:

- introducing BAT in all sectors
- making all industries comply with the C-values
- making industry produce cleaner products
- making industry work more actively with environmental management systems
- implementing the VOC-directive and by taking part in the making of new directives within the area
- laying down guiding limit values for all relevant substances. For dioxins these values will be published in 2001
- taking part in the preparation of BAT notes for relevant sectors
- making agreements on the reduction of emissions with the industry.

When deciding what is to be considered BAT, pollution must primarily be prevented by using cleaner technology (substitution, minimising the use of raw materials and energy, using closed systems etc.) and secondarily the unavoidable pollution must be minimised by using pollution preventing measures such as cleaning.

For SO_2 and NO_x clear reduction targets have been set. Industry shall contribute to the reduction of SO_2 emissions with 80% by the year 2000 compared to the emissions by the year 1988, and contribute to the reduction of NO_x emissions with 30% in 1998 compared to the emissions in 1985.

Other initiatives for the industry will be in pursuit of the general objectives and instruments for the integrated product policy, chemicals, Energy 21 and the Government's waste plan 1998-2004 (Waste 21).

5.3.2 Environmental objectives of energy supply

The objectives on reducing air pollution from the energy supply mainly focus on emissions of SO_2, NO_x, heavy metals, (and CO_2). Emissions from heat and power production in Denmark are minimised and extensively controlled

---

[57] The approval scheme of the EPA corresponds largely to the approval scheme of the IPPC directive.

through fuel quality (sulphur content), combustion technology (low-NO_X burners, etc), filters, flue gas desulphurisation, NO_X control (selective catalytic reduction, etc.) and energy conservation.

The Government's overall environmental goal on the energy area is to reduce the CO_2 emissions by 20% in 2005 compared to the level in 1998 and to reduce the emissions of other waste products significantly.

In order to attain these targets as well as a number of international goals, the Government drew up an energy action plan, Energy 21, in 1996. According to this plan, energy consumption must be stabilised while streamlining energy production and using renewable energy in the energy supply to a greater extent instead of fossil fuels. The intention is thus for renewable energy to account for 35% of the total energy consumption in 2030. A wide range of management tools is being used to implement this plan.

In March 1999 the Danish Parliament concluded an agreement regarding a new reform for the electricity area. According to this agreement, Denmark will be the first country to introduce a market for CO_2 quotas, which place an annual ceiling on the emission of CO_2 by the electricity sector. Furthermore, in future all electricity consumers must receive an increasing part of their power from renewable energy.

Regulation of the energy supply takes off in the acts on electricity, heating and natural gas supply. Further, it is supplied by a goal directed policy on subsidies, taxes and charges. Finally, there is a tradition for making agreements between the state and the energy sector. Agreements have been made on establishing windmills and the use of biomass.

5.3.3 Environmental objectives of transportation

Danish objectives on transport with relation to air pollution are laid down in the action plans Transport Action Plan, 1990, Traffic 2005, 1993, and the Danish Government's Action Plan to Reduce the CO_2 Emissions of Transport, 1996.

Controls on transportation emissions include fuel quality (lead, sulphur), emission standards for new vehicles (vehicle technology), inspection and maintenance, incentives to limit ownership and use of private vehicles, subsidies and incentives for public transportation, electrification of trains and buses (moves emissions to power plants).

Objectives with relation to air pollution, compared to 1988-levels, are:

- NO_x and HC emissions are to be reduced with at least 40% before year 2000 and 60% before year 2010. Further reductions up to 2030 shall take place.

- Particulate matter emissions in the towns and cities shall be reduced with 50% before 2010. Further reductions up to 2030 shall take place.

- 4% of transport by cars shall be replaced with bicycle or walk before 2005.

Air pollution (other than CO_2) from the transport sector has declined during recent years as a result of emission standards for new cars. However, the transport sector is not on a sustainable path. Negative impact on human health and environment is still a big issue.

In order to bring about more environmentally friendly goods transport, a panel was established in 1998 with participation of the transport sector and transport buyers, among others.

In order to limit environmental and health problems in the cities, the Government in 2000 granted the municipalities statutory authority to introduce experiments with traffic-regulating measures solely for environmental and health purposes, that is, areas where special environmental or health require-ments may apply. Furthermore, promoting local plans for traffic and environ-ment in the context of local Agenda 21, the regional and municipal planning and the urban political effort must support a sustainable transport policy at county and municipality level.

The Danish action plans on traffic, the EU-legislation and Danish environmental-traffic law have introduced a very complicated regulation system of the transport sector based on standards, norms, sector plans, physical plans and economic instruments. The Danish legislation to combat pollution from transportation in general reflects the EU initiatives taken. The legislation concentrates on cars.

5.3.4 Legislation on air pollution

Environmental Protection Act

Concrete regulation
Air pollution is under EPA regulated by concrete decisions such as environmental permits, prohibitions and orders under the act. Please refer to section 5.4.1 and 5.4.2 for a description of the environmental permit system and air pollution.

General regulation
The Minister has under the provisions of EPA published three orders of relevance to *ambient air quality*. Two orders on limit values for the content of SO_2 and particles and of NO_2 in ambient air[58]. Both orders are to be amended as a result of the Danish implementation of the Air Quality Framework Directive and its daughter directives. Furthermore, there is order on monitoring and assessing the content of ozone in ambient air[59]. The Order contains rules on monitoring and assessing the content of ozone in ambient air and for giving notice to the public when threshold values are exceeded[60].

The Minister has under the provisions of EPA published several Statutory Orders on reduction of air pollution from *the industry, including from the heating industry, power plants and farms*, including on emissions of asbestos; emissions of nitrogen dioxide, unburned hydrocarbons and carbon monoxide from gas engines and gas turbines; emissions of sulphur dioxide, nitrogen oxide and dust from power plants; the content of sulphur and other substances in fuel,

[58] Statutory Order no. 836 of 10 December 1986 on limit values for the content of SO_2 and particles in ambient air; Statutory Order no. 119 of 12 March 1987 on limit values for the co n-tent of NO_2 in ambient air.
[59] The Order implements directive 92/72.
[60] Statutory Order no. 184 of 11 March 1994.

which might cause pollution; the storage and treatment of farmyard manure and silage.

The most important regulations are:

- Order on approval etc. of waste combustion plants[61]. The order contains provisions that implement directive 94/97 on combustion of dangerous waste. It lays down rules on the establishment and running of a combustion plant for dangerous waste. Further, it requires the environmental authority to comply with the requirements on limit values, conditions and monitoring methods given under the Order when issuing environmental permits (waste combustion plants are subject to environmental permits).

- Order on waste combustion plants[62]. The order contains provisions that implement directive 89/369 and 89/429. The Order requires the environmental authority to comply with the requirements on limit values, conditions and monitoring methods given under the Order when issuing environmental permits (waste combustion plants are subject to environmental permits).

- Order on reduction of emissions of SO_2, NO_x and dust from large power plants[63]. The Order refers to directive 88/609. The Order lays down limit values, conditions and monitoring methods for large power plants.

- Order on reduction of emissions of asbestos to ambient air from industrial plants[64]. The Order refers to directive 87/217. The order lays down limit values, conditions and monitoring methods for industrial plants.

Several Danish statutory orders have been issued under the provisions of legislation administrated by the Ministry of Transport, but also under the provisions of EPA and Act on Chemical Substances and Products, mainly to implement EU legislation on (road) *transport*, including legislation on new vehicle emission standards[65]; content of polluting substances, such as sulphur dioxide, in fuel; emissions from vapour and distribution of petrol; and inspection and maintenance.

The most important regulations are:

- Order on the quality of petrol and diesel oil for vehicles etc[66]. The Order contains provisions that implement directive 98/70. The Order lays down limit values for the content of a number of substances in petrol and diesel oil for vehicles.

- Order on environmental requirements when establishing and running a garage, etc[67].

- Order on reduction of discharges of vapour when filling up the automobile tank with petrol[68]. The Order lays down rules on the establishment and running of installations to fill up the vehicle with petrol and diesel.

---

[61] Statutory Order no. 660 of 11 august 1997.
[62] Statutory Order no. 41 of 14 January.
[63] Statutory Order no. 689 of 15 October 1998.
[64] Statutory Order no. 792 of 15 December 1988.
[65] Denmark required catalytic converters before it became mandatory in EU.
[66] Statutory Order no. 529 of 25 June 1999.
[67] Statutory Order no. 922 of 5 December 1997
[68] Statutory Order no. 643 of 28 July1997.

- Order on reduction of air polluting emissions from mobile off-roaders[69]. The Order contains provisions that implement directive 97/68. The Order lays down rules on labelling and marketing of engines for off-roaders.

- Order on reduction of discharges of vapour when storing and distributing petrol[70]. The Order contains provisions that implement directive 94/63. The Order lays down rules on establishment and running of terminals and gas stations with the aim of reducing loss of petrol by evaporation.

Act on Chemical Substances and Products
As mentioned above, also the Act on Chemical Substances and Products authorises the minister to lay down rules with the aim of protecting health and the environment.

The most important regulations are:

- Order on spraying with chemical substances from aeroplanes[71];

- Order on the use of ozone depleting substances[72]. The Order prohibits the use of a number of ozone depleting substances.

5.4 Regulatory instruments

5.4.1 Guidelines/Norms

DEPA has issued two guidelines that are used as administrative and technical basis for laying down environmental conditions concerning air pollution in environmental permits and other administrative decisions (prohibitions and orders) under the Environmental Protection Act.

The most important guideline is *Guidelines No. 6/1990 on Limitation of Industrial Air Pollution*[73].

The Guidelines on Limitation of Industrial Air Pollution are based on the principles of e.g. replacement of air pollutants by other less critical substances; reduction of resource consumption and the use of less polluting production methods in enterprises; and employment of the best available technology. The authority shall take into consideration e.g. health – both direct health-related effects of air pollution and indirect pollution by the transfer of airborne substances into water and food – when laying down requirements to industry, etc. The Guidelines lay down limit values on emissions and ambient concentrations of a number of air polluting substances. The values are based on existing (at that time) knowledge on their harmful influence on health and environment. The principles for derivation of the health-based guidance values and the C-values, together with a table of the values of about 450 substances are

[69] Statutory Order no. 667 of 14 September 1998.
[70] Statutory Order no. 852 of 11 November 1995.
[71] Statutory Order no. 185 of 15 May 1981
[72] Statutory Order no. 974 of 13 December 1995
[73] These guidelines are not any longer in harmony with the EU air quality norms. The outdated guidelines were criticised in a decision made the Appeals Board of Environmental Protection to assess and to change the target loads of these guidelines. To those who manage or intend to establish enterprises that cause or might cause air pollution problems, these guidelines also indirectly indicate the conditions they may generally presume that they will have to comply with.

given in appendix 1. The Guidelines are now being revised to clarify and simplify some procedures to ease the approval process. The revised Guidelines will clarify requirements for use of best available technology (BAT) and harmonise the guidelines with recent EU directives.

Furthermore, there is *Guidelines no. 4/1985 on Industrial Odour Control*, as nuisance from odour in some cases occur at lower levels compared to a level based on health protection, i.e. odour may in some cases be the most critical emission from an industrial plant.

As mentioned above, orders on approval etc. of waste combustion plants, and reduction of emissions of SO_2, NO_x and dust from large power plants[74] lay down rules on the establishment and running of waste and power plants, lay down limit values for emissions of a number of substances, and set up monitoring methods. The orders require the environmental authorities to comply with the provisions under the orders when making decisions under the Environmental Protection Act, for example when issuing environmental permits.

5.4.2 Approvals, etc.

As mentioned in chapter 3, section 3.5.2, certain types of polluting enterprises, plants or activities[75] - entered on the list on activities to be approved[76] - cannot be established or commenced without prior approval from the environmental authority. Such an approval is called environmental permit. Neither shall they be extended or modified without prior approval if those extensions or modifications will result in increased pollution.

The environmental permit includes the prior approval of air polluting emissions and might include conditions laid down with the aim of reducing air pollution.

Furthermore, under the EPA, the environmental authority is authorised to lay down requirements on industry etc., that are not subject to environmental permit, including laying down conditions for emissions and ambient concentrations of air polluting substances. The requirements are laid down in prohibitions and orders.

Air pollution reducing conditions under environmental permits or under prohibitions and orders are primarily based on Guidelines on Limitation of Industrial Air Pollution.

5.4.3 Environmental impact assessment

Some activities are subject to Environmental Impact Assessment. Activities subject to EIA are listed in Order no. 428 of 2 June 1999 on supplementing rules under the Planning Act. The assessment includes an assessment of the harmful health and environmental effects of substances emitted to air.
EIAs are used as planning instruments and as a basis for approvals, permits, etc. under the different environmental acts, such as EPA. A number of the enterprises that are subject to environmental permit (corresponds largely to the IPPC-enterprises under the IPPC-directive), are also subject to EIA (the

---

[74] Statutory orders no. 660 of 11 august 1997; no. 41 of 14 January 1997; no. 689 of 15 October 1998.
[75] Cf. EPA art. 33 and 35.
[76] Order no. 807 of 25 October 1999 lists the activities to be approved by the environmental authority.

EIA-list corresponds to the list under the EIA-directive). An environmental permit cannot be issued before the environmental authority has approved the EIA.

5.4.4 Monitoring instruments

The Danish National Environmental Research Institute (NERI)[77] is responsible for the two nation-wide air quality networks in Denmark - the urban network (LMP) and the background network (BOP).

LMP comprises an urban monitoring network with stations in three Danish cities (Copenhagen, Odense and Aalborg, and from 2000 also Aarhus). The results are used for assessment of the air pollution in Danish cities. Following substances are measured: NO, NO_2, SO_2, CO, O_3, particles and heavy metals. The results are currently published in quarterly reports[78]. A permanent smog warning system including NO_2 and O_3 was set up in 1994.

BOP assembles information on nutrient input to the aquatic systems. Measurement is performed at 8 different locations. These locations are selected to represent coastal and island based areas and inland areas. The samples are analysed for their content of nutrients and metal ions. Furthermore, 7 stations are equipped with filter pack samplers to collect compounds in gas or in particle phase. The results are currently published in an annual report.

LMP has been revised in 2000 in order to fulfil the requirements to assess ambient air quality as laid down in Dir. 96/62/EC of 27 September 1996 on ambient air quality assessment and management (Air Quality Framework Directive) and the attached daughter directives.

The Air Quality Framework Directive requires Member States to ensure that a plan or programme is prepared for attaining the limit values within specific time limits in zones where levels are higher than the limit values. Further, it requires, in the event that the alert thresholds are exceeded, that Member States shall undertake to ensure that the necessary steps are taken to inform the public.

5.4.5 Planning instruments

Major power plants are regulated through county approvals on environmental impact assessments and environmental permits of the plants.

Traffic 2005 (1993) and the Danish Government's Action Plan to Reduce the CO_2 Emissions of Transport (1996); Energy 21 (1996), the Aquatic Environment Plans I and II (1987 and 1998) are all administrative planning instruments aiming at defining goals and instruments with the aim of combating air pollution.

5.4.6 Environmental agreements

In 1994, an environmental contract for reducing the emissions of VOCs was made between the Confederation of Danish Industries and the Minister. The character of the contract is primarily that of an action plan for the relevant

[77] See www.dmu.dk and links given here.
[78] They are summarized in annual reports in English.

branches. It is based on technical statements about the possible technical and economic barriers to reduction. For the industry the advantage of this contract lies precisely in the contract itself, as DEPA promised, already in 1989, not to raise the threshold limits for VOCs in air quality guidelines if the industry would prepare a plan for substantial reduction of VOC emissions by the year 2000.

5.4.7 Quotas

Emissions on SO_2 and NO_x are regulated through a quota system for the power plants. Every year the amount of permissible SO_2 and NO_x emissions is set up for the major power plants.

5.4.8 Economic instruments

For economic instruments aiming at reducing polluting emissions to air please refer to chapter 3. Product taxes/charges are laid down to reduce air pollution on vehicles, fuels and certain substances. There are taxes on the content of sulphur in fuels; annual vehicle taxes related to the level of air pollution from each type of vehicle; CFC tax; CO_2 tax; and tax on chlorinated solvents.

5.5 Actors

The primary actors concerning regulation of air pollution are listed in Table 5.7. For general descriptions of the mentioned actors please refer to chapter 3.

Table 5.7 Actors, roles and responsibilities concerning air pollution

Actors	**Roles and responsibilities concerning air pollution**
State level	At state level that main actor concerning air pollution in general is the DEPA. DEPA lays down policies and objectives concerning combating air pollution and prepares draft acts, statutory orders and guidelines to reduce air pollution. Finally, DEPA provides guidance for the work of the regional and local authorities and supports research and development.
DEPA	DEPA is responsible for the continuous elaboration of C-values and air quality criteria. The work is coordinated and supervised in a forum including representatives from the Ministry of Food, Agriculture and Fisheries, and the Ministry of Health.
Ministry of Transport	The Minister of Transport, in co-ordination with the Minister of Environment and Energy (DEPA and the Danish Energy Agency), lays down policies and objectives and adopts most regulation concerning the transport sector. The Ministry supports research and development.
Ministry of Finance	The Ministry of Finance (Finansministeriet) adopts any legislation concerning economic instruments – also with the aim of reducing air pollution.
Other ministries	The Ministry of Food, Agriculture and Fishery (Ministeriet for Fødevarer, Landbrug og Fiskeri) is involved in reducing the air pollution from the agricultural sector. The Ministry of Trade and Industry (Erhvervsministeriet) is involved in reducing the air pollution from industry. In 1998, a common task group for assessment of the health implications of the EU limit values for air pollutants was established. The group embraces the National Board of Health and the Ministry of Environment and Energy just as other experts are part of the group.
National Environmental Research Institute of Denmark (NERI)	NERI is the main actor concerning the running of LMP and BOP. See section 5.4.4 for a description of LMP and BOP. Furthermore, part of the work in the Ministry of Environment and Energy is done under the consultation of NERI.
Counties and municipalities	Counties are responsible for the monitoring and assessment of the ambient air quality[79]. Counties and municipalities, in order of the environmental protection act, lay down requirements for emissions of air polluting substances from industry and agriculture[80] and supervise compliance with law[81].
The medical officer on health	The medical officer on health provides the environmental authorities with his or her expertise on health related matters, also concerning health related effects of air pollution. Furthermore, the medical officer on health can complain of a number of environmental decisions, including environmental permits, to the environmental appeal boards. The officer can e.g. complain of decisions/conditions which, in his or hers view, can lead to harmful effects on health.

79 EPA art. 6, subsection 1.
80 EPA art. 33 and 35 and 42.
81 EPA art. 65, 66 and 68.

Actors	Roles and responsibilities concerning air pollution
Danish Industry	In the booklet "More energy and environment at less cost", DI identifies the instruments which according to DI should be preferred for incorporation into the Danish energy policy.
Power Plants	The Association of Danish Power Plants[82] represents its 150 members and their interests concerning economy, energy and environment in a dialogue with Parliament, Government, authorities and private enterprises. The Danish power plants play a large role in the Danish energy and environmental policy with relation to air pollution. During the years the power plants have been subject to several state initiatives concerning the use of biomass fuel, the establishment of wind mill parks, the change-over from coal and oil to gas and bio mass fuel, taxes on SO_2 and CO_2 emissions, etc.
Oil Industry	The oil industry is represented through a number of co-operatives, here the relevant one is the Oil Industry's Co-operation. It issues yearly publications, statistics, etc. The oil industry is not a big industry in Denmark. Denmark is an oil and gas producing country, but it only administrates limited resources. All oil and gas exploration takes place in the North Sea. There are a small number of Danish oil refineries. Oil refineries are subject to environmental approval (by the county). Oil and gas installations at sea are subject to rules on environmental impact assessment (the Danish Energy Agency approves the EIA). Conditions are laid down under the environmental permits/approvals to exploit and explore oil and gas to reduce air pollution.
Transport Sector	Traffic is one of the most significant sources of air pollution in Denmark. There are a large number of small and big transport companies in Denmark, representing both road, air, and rail. The sector is represented through a number of organisations.

5.6 Evaluation

The overall goal in relation to air quality is to achieve a quality without any adverse health effects to the public. Because of the present levels of air pollutants a more realistic objective of today, however, is to further reduce the levels of "classical air pollutants" in order to minimise any harmful impact on public health. For several pollutants it has not been possible to identify lower thresholds for effects e.g. for particulate matter and ozone as well as for carcinogens such as benzene and Benzo(a)pyrene. Based on international studies, the observed levels of fine particles ($PM_{2.5}$) and ozone in Denmark would imply significantly increased mortality and illness among sensitive groups: persons with existing respiratory illnesses and persons with heart disease. These groups make up a substantial fraction of the population. The level of these health impacts is only roughly estimated in Denmark, because there has been limited Danish research on this, and monitoring of fine particles has not even started in Denmark.

The average daily human exposure to dioxins in Denmark is also in recent Danish studies estimated to exceed the WHO guideline for tolerable daily intake, but is not clear to which extent such an exposure level contribute to effects in the Danish population.

That fact that current air pollution levels seem to imply significant health effects in the population indicates that the level of protection is considerably lower than for soil and water pollution. In these other media, limit values are

[82] www.home7.inet.tele.dk

set considerable below effect levels, and there are mandatory actions to remove the problem if limit values are exceeded. The EU framework directive on air quality management requires only planning to attain the ambient air quality limit values where they are exceeded, without specifying mandatory actions to take.

Reduction of fine particulate pollution will be a significant challenge in the coming years. The limited observations of PM_{10} indicate that the EU limit values for $PM_{10,}$ which will become effective in 2005 and 2010, are presently exceeded in Copenhagen. International experience indicates that particulate levels will be very difficult to reduce.

The occurrence of high ozone levels in Denmark is usually associated with transport of photochemical pollution from areas south of Denmark. Reduction of health impacts from ozone in Denmark will thus require a concerted effort throughout a large part of Europe. Fine particles are also transported long distances, which will also make control of fine particulate pollution in Denmark dependent on control in other countries.

Ultrafine particles have recently received a lot of attention in health impact research, and indications are that these tiny particles have a large impact on health. Research measurements of ultrafine particles have begun in Denmark, but there is not yet international consensus on standard measurement techniques for ultrafine particles. Further assessment of the effects of these particles is a challenge for the future.

There is a general trend of air pollution concentrations being lowered. Ambient levels of most of the primary air pollutants have been declining over the past decade due to improvements in energy production and the require-ment of catalytic converters on new cars since 1990. However, the decline of NO_2 in urban areas has been rather weak, as the ozone concentration is the determining factor. The coming improvements in EU vehicle emission standards, fuel quality standards, plus required improvements at large industries in the EU, will continue to generally lower emissions, in spite of increasing vehicular traffic in Denmark.

It is generally accepted that industrial emissions of air pollutants is well regulated as the result of an effective approval (permit) system which has essentially achieved mandatory requirements for limitation of industrial emissions and the resulting ambient concentrations. The C-values and associated emission limits in this system have been established based on health risk assessments of each specific substance.

The new and planned EU air quality directives, and related vehicle, fuel and industrial directives, will establish consistent limit values for additional pollutants, and vehicle and large-industry requirements in all EU member states. These directives will provide continued reductions in the transboundary pollution that has health impacts in Denmark. The possibility and the need for further reduction of limit values should be regularly reviewed, as well as the need for limit values on additional pollutants, such as ultrafine particles.

It is vital to obtain a better characterisation of the different size fractions of ambient particulate pollution, and the exposure and impact on the population. There is also a need for increased knowledge of techniques for reduction of particle emissions from the various sources, such as filters on diesel vehicles.

There is a need for further research on sources of dioxin and substances with similar properties and on the possibilities for further control and reduction of these pollutants.

5.7 References

Centers for Disease Control and Prevention (2000): "*1,3-Butadiene ATSDR Fact Sheet*" (http://aepo-xdv-www.epo.cdc.gov/wonder/prevguid/p0000463-/p0000463.htm).

DEPA (1992): "*Industrial Air Pollution Control Guidelines*". Vejledning fra Miljøstyrelsen Nr. 9.

DEPA (1995): "*Nationale og industrielle emissioner af 38 stoffer*". (National and industrial emissions of 38 substances.) Working Report no. 64, Danish Environmental Protection Agency.

DEPA (2000): "*Flow analysis for Dioxins in Denmark*". by E. Hansen and S. Skårup. Environmental Project no. 570, Danish Environmental Protection Agency.

HEI (2000): "*1,3-Butadiene: Cancer, Mutations, and Adducts*". Research Report No. 92, by Rogene F. Henderson, Leslie Recio, Vernon E. Walker, Ian A. Blair, James A. Swenberg. Health Effects Institute (HEI), Cambridge, Massachusetts, March 2000, 234 pp.
http://www.healtheffects.org/Pubs/Butadiene-S.pdf

Karsten Revsbech (1999): "*Lærebog i miljøret*" (Textbook in Environmental Law).

Ludwig Krämer (2000): "*EC Environmental Law*".

Larsen, P.B. et al. (1997*): "Sundhedsmæssig vurdering af luftforurening fra vejtrafik" (*Evaluation of the health impacts of air pollution from road traffic). Miljøprojekt nr. 352, Miljøstyrelsen.

Larsen, P.B. (1999): "*Hvordan vurderer Miljøstyrelsen effekten af luftforurening" (*How the Danish EPA assesses the effect of air pollution). Kontoret for Biocid- og Kemikalievurdering, Miljøstyrelsen. Paper presented at the IDA Meeting, 4 November 1999, 7 pp.

Ministry of Environment and Energy (1999): "*The Danish Nature and Environment Policy*".

Ministry of Environment and Energy (1993 and 1999): "*EU, Denmark and the Environment*", paper to be found on http://www.mst.dk/199909publikat/87-7909-412-0/helepubl.htm.

Ministry of Environment and Energy (1999): Natur- og Miljøpolitisk Redegørelse 1999, afsnit 15.1.3 Indeklima og luftforurening, Miljø- og Energiministeriet, http://www.mem.dk/publikationer/nmpr99/kapitel15.htm - 15.1.3.

Ministry of Environment and Energy (2000a): "*Partikler*" (Particles). Draft internal working paper of the Interministerial Working Group on Air Pollution, Ministry of Energy and Environment and the National Health Agency (Sundhedstyrelsen), 7 August 2000, 20 pages.

Ministry of Environment and Energy (2000b): "*Ozon*" [ozone]. Draft internal working paper of the Interministerial Working Group on Air Pollution ("luftgruppen"), Ministry of Energy and Environment and the National Health Agency (Sundhedstyrelsen), 8 August 2000, 14 pages.

Kemp, K, and F. Palmgren (1999): "*The Danish Air Quality Monitoring Programme; Annual report for 1998*". NERI Technical Report No. 296. National Environmental Research Institute.

NERI (2000): "*The Danish Urban Air Quality Network*" (LMP) (http://www.dmu.dk/AtmosphericEnvironment/aq_besk/lmp.htm)

Finn Palmgren, Peter Wåhlin, Ruwim Berkowicz & Ole Hertel (1999): "*Ultrafine partikler - luftforurening fra trafikken og befolkningseksponering*". Paper presented at the conference Dansk Miljøforskning 1999. (http://www.dmu.dk/miljoekonference1999/online/abstracts.htm)

Peter Wåhlin, Finn Palmgren and Rita van Dingenen (1999). Experimental Studies of Ultrafine Particles in Streets and the Relationship to Traffic. Poster presentation. Presented at "International Conference: Air Quality in Europe: Challenges for the 2000s" Venice 19-21 May 1999. Poster to be submitted as paper in a special number of Atmospheric Environment. (http://www.dmu.dk/atmosphericenvironment/docs/particles.htm)

WHO (2000): "*Guidelines for Air Quality*". (http://www.who.int/peh/air/Airqualitygd.htm)

WHO (1994): "*Update and revision of the air quality guidelines for Europe, meeting of the working group "classical" air pollutants*", Bilthoven, The Netherlands 11-14 October 1994, WHO Regional Office, Copenhagen 1995.

WHO (1996): "*Particulate matter*". World Health Organisation Air Quality Guidelines for Europe 1996. Final edited draft, September 1997.

<u>Danish legislation</u>

Environmental Protection Act, cf. Consolidated Act no. 698 of 22 September 1998 and subsequent amendments.

Act on Chemical Substances and Products, cf. Consolidation Act no. 21 of 16 January 1996 and subsequent amendments.

Statutory order no. 836 of 10 December 1986 on limit values for the content of SO_2 and particles in ambient air;

Statutory order no. 119 of 12 March 1987 on limit values for the content of NO_2 in ambient air.

Statutory order no. 184 of 11 March 1994 on monitoring and assessing the content of ozone in ambient air.

Statutory order no. 660 of 11 august 1997 on approval etc. of waste combustion plants.

Statutory order no. 41 of 14 January on waste combustion plants.

Statutory order no. 689 of 15 October 1998 on reduction of emissions of SO_2, NO_x and dust from large power plants.

Statutory order no. 792 of 15 December 1988 on reduction of emissions of asbestos to ambient air from industrial plants.

Statutory order no. 529 of 25 June 1999 on the quality of petrol and diesel oil for vehicles etc.

Statutory order no. 922 of 5 December 1997 on environmental requirements when establishing and running a garage, etc.

Statutory order no. 643 of 28 July 1997 on reduction of discharges of vapour when filling up the automobile tank with petrol.

Statutory order no. 667 of 14 September 1998 on reduction of air polluting emissions from mobile off-roaders.

Statutory order no. 852 of 11 November 1995 on reduction of discharges of vapour when storing and distributing petrol.

Statutory order no. 185 of 15 May 1981 on spraying with chemical substances from aeroplanes.

Statutory order no. 974 of 13 December 1995 on the use of ozone depleting substances.

Statutory order no. 807 of 25 October 1999 on activities to be approved by the environmental authority.

Guideline no. 6/1990 on Limitation of Industrial Air Pollution.

Guideline no. 9/1992, Industrial Air Pollution Control Guidelines.

Guideline no. 4/1985 on Industrial Odour Control.

Guideline no. 15/1996, B-værdier.

<u>EU legislation</u>

Directive 1999/13/EEC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations.

Directive 96/92/EEC of 27 September 1996 on ambient air quality assessment and management (Air Quality Framework Directive)

Directive 99/30/EEC on limit values for sulphur dioxide, oxides of nitrogen, particulate matter and lead in ambient air. (the first daughter directive).

Directive 92/72/EEC of 21 September 1992 on pollution of ozone.

Directive 89/369/EEC of 8 June 1989 on prevention of air pollution from municipality waste combustion plants.

Directive 89/429/EEC of 21 June 1989 on reduction of air pollution from existing municipality waste combustion plants.

Directive 88/609/EEC on reduction of certain air polluting emissions from large power plants.

Directive 87/217/EEC of 19 March on prevention of pollution of asbestos.

Directive 98/70/EEC of 13 October on the quality of petrol and diesel oil, and amendment of directive 93/12.

Directive 97/68/EEC of 16 December 1997.

Directive 94/63 of 20 December 1994 on prevention of emissions of VOCs when storing and distributing petrol from terminals and gas stations.

<u>International accords</u>

The 1985 Vienna Convention for the Protection of the Ozone Layer, including the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer;

The 1979 Convention on Long-range Transboundary Air Pollution and its Protocols:

- the 1984 Protocol on the Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of Long-range Transboundary Air Pollution
- the 1988 Protocol on the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes
- the 1991 Protocol on the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes
- the 1994 Protocol on Further Reduction of Sulphur Emissions
- the 1998 Protocol on Heavy Metals
- the 1998 Protocol on Persistent Organic Pollutants
- the 1999 Protocol on Long-range Transboundary Air Pollution to Abate Acidification, Eutrofication and Ground-level Ozone.

The Vienna Declaration and the Programme of Joint Action adopted by the UN/ECE Regional Conference on Transport and the Environment at the Ministerial Level, 1997.

Charter on Transport, Environment and Health at the WHO Third Ministerial Conference on Environment and Health, 1999.

6 Soil

Soil is the media for the production of food and clothing materials and the reservoir of drinking water. It is also the media on which we settle to live. Therefore, a clean soil environment is essential to human health.

The soil is constantly influenced by human activities in the form of agriculture, industrial activity, extraction of various minerals, landfills, deposition of airborne pollutants from heat and power production, industrial activities, traffic, waste incineration etc. Deterioration of the soil quality or contamination with chemical substances harmful to human health may be the consequence of this influence.

Apart from deliberate soil treatments and depositions (e.g. use of pesticides and deposition of waste in dumpsites), the influence is mainly an undesired result of a large range of activities, which include both effects from spillage and leakage of chemicals and deposition of airborne contaminants.

This chapter will focus on the regulations connected to environmental factors in soil, which potentially have an impact on human health.

6.1 Human exposure to environmental factors

6.1.1 Environmental factors

Environmental factors in soil are numerous. The primary factors of concern in Denmark are summarised in table 6.1.

Table 6.1 Summary of the origin, characteristics and health impacts of critical soil pollutants.

Environmental factor	Origin and characteristics	Potential Health Impact
Heavy metals e.g. lead	Deposition of emissions from industrial activities and traffic. Lead primarily originates from traffic exhaust due to prior use of leaded petrol	Lead is a neurotoxicant causing impaired IQ, impaired concentration, hyperactivity. Children are considered a special risk group in relation to lead exposure and adverse effect
Polyaromatic hydrocarbons (PAH) e.g. Benzo(a)pyrene (BaP)	Deposition of airborne PAH´s primarily emitted from traffic. PAH’s in the soil may also stem from spillages and deposition of tar products (tar and asphalt production, gasworks, impregnation of ropes and fishing net, wood preservation, tar paper production, etc.)	Potent carcinogenic substances in relation to oral, dermal and inhalational exposure
Chlorinated solvents (tetrachloroethylene, tetrachloromethane, 1,1,1 trichloroethane, trichloroethylene)	Used for degreasing in metal manufacturing processes and dry-cleaning. Also used in some tanning activities, paint production etc.	• Carcinogenic effects • Organ toxicity (kidney, liver) • Neurotoxicity

Environmental factor	Origin and characteristics	Potential Health Impact
Aromatics (benzene, toluene, ethylbenzene and xylene, C_9-C_{10}-aromatics)	Leakage from fuel storage and handling, and spillage related to the production of glues, paints, solvents etc.	• Carcinogen (benzene) • Neurotoxicity • Odour at low levels
MTBE (methyl-tert-butyl-ether)	Additive in gasoline	• Liver and kidney toxicity • Carcinogenic effects found in animal experiments at high exposure level • Odour at low levels
Pesticides/biocides	Pesticides/biocides are frequently identified in water abstraction borings. Both point sources (spillage) and treatment of farmland and other areas are considered to cause groundwater contamination.	May embrace: • Acute toxic effects • Neurotoxic effects • Carcinogenic/ mutagenic effects • Repro-toxic effects • Neurotoxic effects
Phenols	About 10 % of tar consist of phenols. Phenols in the soil environment are therefore mainly related to tar handling activities. Clorinated phenol is a by-product from pesticide production.	• Acute toxic • Organ toxicity (lungs, heart, liver, kidneys, blood) • Carcinogenic effects • Odour at low levels

6.1.2 Sources of pollutants

Point Sources

Much soil is contaminated due to former land use. Industrial and trade activities have over time lead to a large number of contaminated sites. Inappropriate handling of chemical substances and oil-products has caused spillage and leakage of chemicals and oil-products to the soil environment within a wide range of activities:

Production of chemical products, e.g.
- pesticides and biocides
- pharmaceutical industry

Heat and power production, e.g.
- gasworks
- power stations

Manufacturing processes where chemicals are used as ancillary materials, e.g.
- metal industries
- tanning
- dyeing

Final consumption of chemical substances, e.g.
- dry-cleaning
- tarring of fishing net
- wood preservation

Other contamination of soil has occurred in connection with storage of liquid fuels related to petrol retail sales and depots, industrial and trade activities (e.g. tile works and glass production) and oil-heated private homes.

Most of these sites are situated in urban areas, which implies that a part of the population potentially may be affected by problems arising from contaminated soil. Furthermore, many residences have been built on such sites at a time when general acknowledgement of soil contamination was lacking, and therefore may be without any protection against the harmful substances.

The total number of sites that can be affected of former industrial and other polluting activities is estimated to include about 30,000 of which 14,000 are expected to be contaminated. The counties have identified most of these sites since the first legislation came into force in 1983. Public investigations of about 8,000 have lead to the registration of about 6,000 sites of which about 1,400 have been deregistered or released for specific use. As per 31/12 1999 the total number of registered contaminated sites in Denmark amounted to 4,940.

Of these 4,940 sites, 1,830 are prioritised sites expected to be included in the public clean-up effort. 617 sites hereof are used for housing or similar, 1,022 are sites that threaten the groundwater and are situated in particularly valuable water abstraction areas, and the remaining 191 sites are both threatening the groundwater in particularly valuable water abstraction areas and used for housing purposes.

In 1999 1.115 sites were cleaned up. 79 projects were financed by public funds, 570 sites were subjected to voluntary clean-up, and 506 sites were cleaned up under other schemes, primarily the scheme of the Oil Industry's Environmental Fund.

Furthermore, the deposition of industrial and domestic waste taking place prior to the regulation of waste deposition has resulted in nearly 2,000 contaminated sites (of which the majority are included in the above mentioned registered contaminated sites). Most of the dumpsites contain organic materials producing inflammable gasses (primarily methane), which might pose a risk for explosion when migrating into houses. Such a case with fatal outcomes has occurred in Denmark.

Diffuse sources

Agriculture
The intensive exploitation of agricultural land affects the quality of the soil. Farmland is affected by the application of pesticides and by the spreading of sludge and fertilisers. About 20,000 km^2 are cultivated in Denmark. It is estimated that the annual treatment of farmland with sludge affects about 300 km^2. The application of pesticides to farmland is mainly considered being a problem due to the risk of leaching to surface- and groundwater. However, the use of sludge may lead to the accumulation of heavy metals in the topsoil, which can be a direct or indirect source of human exposure.

Diffuse airborne contamination
The soil quality, especially in urban areas, is affected by diffuse airborne contamination due to emissions from traffic and incineration of waste and combustion of fuels for heat and power production. The influence of airborne

pollutants has resulted in diffuse contamination of large districts in urban areas. Some of these are considered to pose a risk to humans (in particular children) due to the content of heavy metals (primarily lead) and poly-aromatic hydrocarbons (PAH) in the topsoil. A total area of up to 200 km^2 is expected to be affected by the deposition of airborne pollution. Out of these, approximately 20 km^2 are estimated to be used for sensitive land use such as housing, kindergartens and public playgrounds.

Uncontrolled disposal of contaminated soil
Finally, uncontrolled use and disposal of soil has lead to spreading of contaminated soil, notably in gravel pits, agricultural lands and in urban areas.

6.1.3 Human exposure

The extent of human exposure to environmental factors (harmful chemical substances) from soil depends on the land use, the concentrations in the soil media, and the risk of contamination of other environmental media (groundwater and air).

The ways of exposure to environmental factors from the soil environment can be divided into direct exposure and indirect exposure.

Direct exposure to substances in the soil:

- Ingestion of soil particles/dust
- Skin contact
- Inhalation of soil/dust particles
- Inhalation of substances evaporated from soil (especially indoor climate)

Indirect exposure:

- Ingestion of contaminated crops from contaminated land
- Ingestion of contaminated animal foodstuffs deriving from livestock on contaminated land
- Through contaminated drinking water (ingest, skin contact, inhalation of aerosols) (see chapter 7)
- Through contaminated fish
- Through bathing water (see chapter 8)
- Through clothing materials originating from agriculture like flax and cotton (no such production takes place in Denmark)

In Denmark, the most significant exposure routes in relation to regulatory measures are generally considered to be

- Ingestion of soil (children)
- Skin contact with soil
- Inhalation of vapours (evaporation into indoor climate)
- Ingestion of drinking water
- Ingestion of crops from contaminated soil

Risk management are based on these exposure routes, as the soil quality criteria are derived with respect to the direct exposure to soil (ingestion and/ or skin contact with soil), the air quality criteria are related to the evaporation from soil to indoor air and drinking water quality criteria are related to ingestion of drinking water. Only few soil quality criteria (e.g. DDT and cadmium) have been derived to account for contamination of crops and the following exposure through consumption hereof.

Primary exposure routes are summarised in figure 6.1.

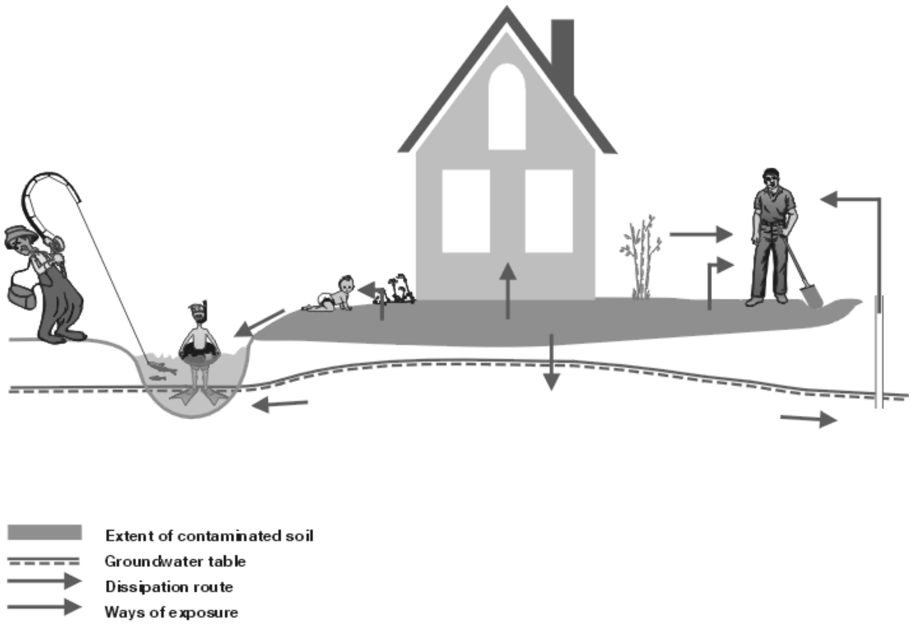


Figure 6.1 Ways of human exposure to environmental factors in soil

6.2 Level of protection

The level of protection is primarily determined by guidelines for risk assessment and by use of health based quality criteria. The purpose is to prevent any health hazards in the human population caused by chemicals as pollutants. In order to fulfil this objective the precautionary principle is used in risk assessment, in derivation of health based quality criteria using safety factors and in designing the level of protection to the most sensitive target group: Small children. The resulting level of protection is considered high compared on an international scale as elaborated in the following sections.

6.2.1 Risk assessment

In November 1998, a guideline on Remediation of Contaminated Sites was issued (DEPA 1998.). It provides a detailed description of the management of contaminated sites including guidelines for risk assessment, field survey methods, collection of samples, site characterisation, and implementation and control of remedial actions.

Guidance for risk assessment is an important tool in evaluation of soil contamination because the routes of human exposure are complex. The risk assessments concerning contaminated soil are primarily aimed at:

- Risk of ingestion of contaminated soil and/or skin contact
- Risk of contamination of ground-/ drinking water
- Risk of evaporation to indoor air

Usually, risk assessments are based on contaminant concentrations, comparing them with the quality criteria for soil, groundwater/drinking water or air. If the concentration level of a specific contaminant is found to exceed the relevant criterion, the contamination of the site is considered unacceptably high (if the concentration is at the same level as the quality criteria, further evaluations may be necessary). This will result, either in further field investigations to improve the initial risk estimate, in restrictions on landuse, or in remedial action.

Assessing the risk of soil ingest, skin contact and inhalation of dust particles is based on the landuse and the accessibility of the contaminated soil to human exposure (e.g. is the contaminated soil accessible or covered by clean soil, grass, pavement etc.).

Humans are especially exposed to injurious substances on lands used for sensitive purposes like playgrounds, day-care centres and residential gardens including household gardens. Especially children are at risk as they often come into close contact with the soil and often ingest soil directly (small children) or become exposed via contaminated toys and fingers. Moreover, some substances exert their toxic effects via absorption through the skin.

Sites registered in the Danish Inventory of Contaminated Sites are prioritised according to the need for remediation. Since nearly all drinking water in Denmark derives from groundwater, groundwater protection has a very high priority. Quality criteria for groundwater shall thus ensure that the water, when it reaches the consumer, complies with the drinking water quality criteria. Generally, lower priority is given to surface water.

Assessing the risk of ground water contamination is based on calculations of contaminant transport by infiltration. The most significant factors in the calculations are as follows:

- The contamination scenario, i.e. type of substance (mobility/ degradability and other substance characteristics) as well as the contaminant concentration and area.

- Geology and hydrogeology, i.e. types of sediment (clay/sand/lime, organic content, hydraulic conductivity, effective porosity), net precipitation/ groundwater formation, groundwater gradient, pressure gradient between the secondary and the primary aquifer, as well as redox conditions.

The risk assessment is based on the principle that the groundwater zone containing the highest concentration must comply with the drinking water/ groundwater quality criteria.

Assessing the risks from volatile soil contamination in relation to indoor air is based on calculations of contaminant transport by diffusion through pore spaces in the unsaturated zone and transport by convection into buildings through diffusion and gaps in concrete floors. If the estimated contaminant concentration in indoor air exceeds the air quality criterion, the contamination is considered unacceptable.

6.2.2 Quality criteria

For the guidance of public authorities the Danish EPA has laid down provisions as to the quality of soil, air and water. For the protection of human health, the quality criteria for chemical pollutants are set at a level at which exposure to the media is not considered to have any adverse effect on human health. That means that the level of the quality criteria is considered to represent a safety level. Thus, when a quality criteria is exceeded to a minor extent it does not mean that a danger level is reached, rather it should be interpreted as an undesirable reduction of the safety level.

Soil quality criteria are derived to protect against harmful effects from direct exposure to soil. In parallel to this, air quality criteria are derived to account for the evaporation of volatile contaminants into indoor air, and ground water/ drinking water quality criteria are used in connection with wash-out and contamination of the groundwater. The contamination is judged tolerable if none of the relevant media oriented quality criteria is exceeded. If for example a contamination is at or below the level of the soil quality criteria, then the area can be used for most sensitive uses. If, at the same time, the contamination level in groundwater is exceeding the ground water quality criteria, then the contamination is considered unacceptable in relation to protection of the groundwater. Thus, compliance to the soil quality criteria does not automatically secure the contamination of the other media i.e. the degree of evaporation to indoor air or the wash out into the groundwater. Criteria values have been published in the guideline on Remediation of Contaminated Sites (DEPA 1998) and in a report on toxicological quality criteria (DEPA 1995). An updated compilation of the specific quality criteria is given in Appendix 1.

Soil quality criteria

Soil quality criteria are derived with respect to the most sensitive uses of the soil i.e. use for domestic gardens, kindergartens or playgrounds. The intention is to protect small children, as children is considered to be the most heavily exposed group (ingestion of soil, hand - mouth contact), but also because children for several chemical pollutants may be more biological susceptible than adults. The calculation of the soil quality criteria is based on a standard scenario consisting of a child weighing 10 kg who ingests 0,2 g soil per day as an average. For acutely toxic substances, isolated ingestion of 10 g of soil is considered. Average skin contact is set to 1g soil to consider substances with high skin permeability. Another issue in the setting of soil quality criteria is the bioavailability of the substance from the soil. For most substances very little is known and only in one specific case (the quality criteria for nickel) data concerning bioavailablity have been used and influenced the final value. For further details, see Appendix 1, where principles and further details in connection with the calculation of health based quality criteria are described.

In urban areas, the quality criteria is generally exceeded for several substances (especially lead and PAH's). Therefore, a new type of guideline value for soil used for sensitive purposes is introduced. It is called the “cut off value”. If the cut off value is exceeded at sites used for residential use, childcare institutions or public playgrounds, remediation must be performed. If the concentration of a contaminant is in the range between the cut off value and the quality criteria, and the site is used for sensitive purposes, the local authorities inform and advise the public, the landowner and the users of the site. The purpose is to establish hygienic measures and soil-exposure reduction measures in order to reduce the actual exposure and thereby obtain the same level of protection as normally obtained at the soil quality criteria. This is called the "advice to residents interval" as illustrated in figure 6.2. The main principle is to avoid bare soil surfaces that otherwise could lead to direct soil exposure of children, and advice is given on measures to avoid bare soil. This also has the consequence that, although investigations has shown that only minor amount of contaminants can be measured in vegetables grown in slightly contaminated soil, it is recommended not to grow vegetables in contaminated soil, because it is nearly impossible to grow them without having bare soil, which could lead to exposure of humans, especially children.

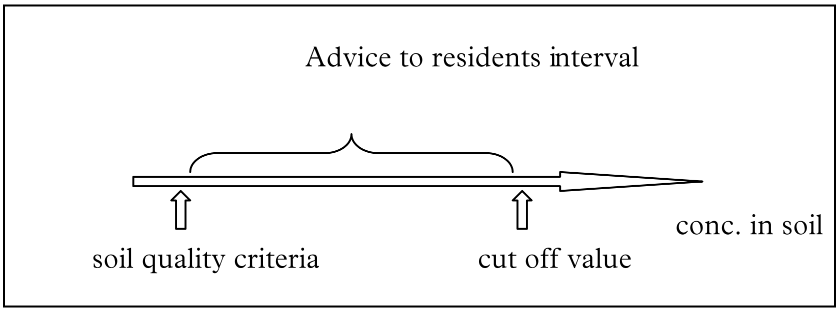


Figure 6.2 Relationship between soil quality criteria and cut off value.

Cut off values can only be used for immobile and rather persistent chemicals and are only set for 10 metals and polyaromatic hydrocarbons.
Examples of quality criteria for soil and cut off values are summarised in table 6.2.

Table 6.2 Topsoil quality criteria for sensitive landuse and cut off values. All units are in mg/kg dry weight.

Pollutant	Quality criteria	Cut off value
Arsenic	20[1(2)]	20[1]
Cadmium	0.5[2]	5[2]
Chromium, total	500[2]	1,000
Chromium (VI)	20[1]	
Copper	500[1]	500[1]
Lead	40[2]	400[2]
Mercury	1[2]	3
Nickel	30[1]	30[1]
PAH, total	1.5[2,3]	15[2]
Benzyl(a)pyrene	0.1[2]	1[2]
Dibenzyl(a,h)antracene	0.1[2]	1[2]
Zinc	500	1,000

[1] Based on acute effect.
[2] Based on chronic effect.
[3] PAH, total defined as the sum of individual components: fluoranthene, benzyl (b+j+k)fluoranthene, benzyl(a)pyrene, dibenzyl(a,h)anthracene, and ideno(1,2,3-cd)pyrene.
Source: DEPA 1998

It should be noticed, that the cut off value and the quality criteria are identical in cases where the quality criteria have been set in order to protect against acute toxic effects, whereas the cut off value may be up to ten times higher than the quality criteria in cases where the soil quality criteria are set to protect against toxic effects from chronic exposure. The rationale for this is that information to the public and risk reduction measures in general are conside-red to have an effect in reducing the *average* exposure of the children. However, these measures may not necessarily secure against single occasions with high oral soil exposure. That means that the cut off value can not be increased compared to the quality criteria, if acute toxic effects have been the basis for the setting of the soil quality criteria.

Quality criteria for evaporation

Assessing the risks from volatile soil contamination in relation to indoor air is based on calculations of contaminant transport by diffusion through pore spaces in the unsaturated soil zone and transport by convection into buildings through diffusion and gaps in concrete floors. If the actual geological and building parameters are not known, standard parameters are used (DEPA 1998). If the estimated contribution to indoor air from evaporation from soil exceeds the air quality criterion for evaporation, the contamination is considered unacceptable.

Danish air quality criteria for evaporation is summarised in Appendix 1. The air quality criteria are also used in outdoor air as emission values to control the emission from industry (see section 5.2.1).

Quality criteria for ground water/ drinking water

The objective is to protect groundwater as a drinking water resource, irrespective of whether abstraction borings are located in the area or not. Drinking water is dealt with in chapter 7 and quality criteria for groundwater/ drinking water are presented in Appendix 1.

Quality standards for waste products

Some provisions have been laid down on the use of sludge, sewage, compost, ash from biomass and other waste products for agricultural purposes (Statutory Order on Sludge no. 49 of 20 January 2000 and Statutory Order on Bio-ash no. 39 of 20 January 2000). These regulations define certain quality standards for the maximum concentration of organic contaminants and heavy metals in waste products to be distributed on agricultural land. These Danish quality standards are substantially lower than given in the EU Directive on Sludge (86/278/EEC), which further more only covers sludge and only gives quality standards for heavy metals.

The concentration of heavy metals in soil may not exceed certain contents if waste products shall be applied. The quality criteria for agricultural soil are defined for seven heavy metals.

Table 6.3 Quality criteria for agricultural soil treated with waste products. All units are in mg/kg dry weight.

Pollutant	Quality criteria
Cadmium	0,5
Mercury	0,5
Lead	40
Nickel	15
Chromium	30
Zinc	100
Copper	40

Source: Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes. (the "Sludge Order").

6.3 Regulation and strategy

6.3.1 Objectives and principles

The primary objective of regulation on contaminated soil is to prevent, eliminate or reduce soil contamination and to hinder or prevent harmful impact of soil contamination on human health, groundwater and the general environment. The precautionary principle is used both in setting quality criteria (principles are explained in appendix 1) and in guidelines for performing risk assessments.

In the early 1970s, authorities in Denmark became aware of the potential problems with some contaminated sites, especially landfills containing chemical waste. The uncovering of buried waste in a number of cases during the 1970s led to enactment of the first legislation dealing with contaminated sites (The Chemical Waste Deposit Act of 1983). During the 1980s it also became clear that landfills containing household waste, and industrial activities, could pose a risk to man and the environment. As a consequence the legislation was revised (The Waste Deposit Act of 1990) in order to include all types of contaminants. Realising that contamination could also result from airborne and other diffuse sources, the Soil Contamination Act was adopted in 1999. Thus, the Soil Contamination Act covers all contamination in soils, irrespective of the time and place of contamination.
However, the act does not apply to soil affected by agricultural application of sludge, fertiliser, and pesticides, etc.

Preventive measures are primarily met in the permits required for any polluting activity as defined in chapter 5 of the Environmental Protection Act and in the incentives for application of cleaner technology. Similarly, rules are set up for regulation of storage of liquid fuels.

General preventive measures are also conducted in the regulation of the use of toxic chemical substances (lead additives in petrol, cadmium and mercury in batteries, chlorinated solvents etc.) and waste management (incineration, separation of waste products, recycling, etc.).

6.3.2 Legislation on soil contamination

The soil contamination act
The Soil Contamination Act[83] entered into force on 1 January 2000, for certain provisions under the act a bit later. The act replaces Act on Waste Deposits.

The Environmental Protection Act regulates the protection of the ground water. It prohibits the discharge of polluting substances on the ground. However, this is not sufficient as there are already a lot of existing waste deposits or areas where the soil is contaminated in Denmark, very often they are situated on areas where there is or have been industry or other polluting activities. The Act on Soil Contamination covers these problems.

[83] Act No. 370 of 2 June 1999.

The objectives of the Soil Contamination Act are:

1. Groundwater protection: Groundwater protection has a very high priority in the Danish policy, as 99% of the water supply is based on the abstraction of groundwater of a high quality usually requiring very limited treatment before it can be used as drinking water.

2. Prevention of health problems arising due to use of contaminated areas. Special attention is paid to small children as a special risk group.

The main principles for the follow up on the objectives are:

1. Provision of the basis for co-ordinated and directed public effort to avoid harmful effects from soil contamination. This basis is primarily provided through the identification and *mapping of contaminated areas.*

2. Prevention of further contamination of the environment in connection with the use and disposal of soil by establishing a *soil management system.*

3. *Liability.* The polluter is the primary party to take the measures required combating the impact of soil contamination and to restore the original state of the environment.

Mapping of contaminated areas
In 1990, the counties systematically started investigating all sites that were being or had been used for activities presenting a potential contamination risk. As a consequence of the Soil Contamination Act, a new system of mapping of contamination is introduced. According to the act, the county council shall carry out mapping, possibly through technical investigations, of contaminated areas in co-operation with the municipal council.

Soil management system
Before transporting soil from a property mapped as contaminated, or mapped as potentially contaminated (because it is in use or has been in use for activities that might contaminate the soil), a notification must be sent to the municipality. The municipality will – in case the municipality disagrees with the proposed disposal - instruct the applicant on how to dispose the soil and on the needed requirements for documentation of the soil quality.
Any receiver of soil excavated anywhere shall ensure that the soil does not harm the groundwater, human health, and the general environment.

Liability and payment of damages
Danish environmental legislation is based on the polluter pays principle. The liability for soil contamination can be considered as both a legal and an economic instrument. The consequences of soil contamination as to payment of damages and restoration can be solved in accordance with:

- The rules of prevention, protection and restoration laid down in the Environmental Protection Act and partly the Soil Contamination Act.
- The rules on administrative orders to the polluter laid down in the Soil Contamination Act.

- The liability law on damages outside of contract or in accordance with the basic legal principles on claims against defects at the sale of polluted real estate.

During the 1990s, several lawsuits revealed that strict liability for contaminated sites cannot be applied within Danish civil law. The Supreme Court ruled against the Ministry of the Environment and Energy in a number of cases where it could not be proved that the polluter was acting in bad faith at the time the pollution occurred. A ruling from the Supreme Court in 1992 states that the normal time limit for liability in cases of soil contamination is 20 years. As a consequence, a polluter cannot be held liable for contamination that took place more than 20 years ago, whether the polluter acted in bad faith or not. As a consequence, the Soil Contamination Act provides for a number of significantly strengthened enforcement powers, primarily to be applied in relation to pollution occurring after January 1, 2001.

Other regulation of soil contamination
The spreading of sludge and uses of fertilisers and pesticides in agriculture are regulated through statutory orders and through the Act on Chemical Substances and Products.

The registration (approval) and use of pesticides is regulated by the Act on Chemical Substances and Products and in more detail by the provisions of the Statutory Order on Pesticides (Statutory Order no. 241 of 27 April 1998 with revisions of 20 December 1998, 25 September 1999 and 5 May 2000). This legislation regulates which pesticides are permitted for use in Denmark and for what purposes, but does not define maximum levels of total loads or frequency of use of pesticides at field level for the approved purposes. Such general goals to reduce total agricultural pesticide consumption and use have been stipulated in the Pesticide Action Plans I and II passed by the Danish Parliament in 1987 and 1999, respectively.

Waste products such as municipal sewage sludge, industrial sludge and compost from domestic and industrial organic solid waste can, under certain preconditions, be used for fertilising and other soil amelioration purposes in agriculture, horticulture and forestry. Such uses of waste products are regulated by Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes (the "Statutory Order on Sludge") in which maximum levels of 8 heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) and 4 organic chemical contaminants (DEHP, LAS, NPE, PAH) as well as maximum application amounts are stipulated. Furthermore, the statutory order contains soil quality criteria that must not be exceeded as a result of the use of sludge or other waste products (manure and garden waste are not comprehended by the statutory order).

6.4 Instruments

6.4.1 Regulatory instruments

Norms
Quality criteria for soil, evaporation to indoor air and for groundwater/drinking water, all aiming at the protection of human health, are among the prima-ry regulatory instruments determining the level of human protection as described in section 6.2.2.

Enforcement notices to the polluter
The Soil Contamination Act defines a set of rules on enforcement notices to the polluter.

An enforcement notice on cleaning up pollution can be given by the municipal or county authority.

The concrete enforcement notice concerning the cleaning up of pollution is given to the polluter, and this can be given irrespective of how the pollution has happened. It is furthermore without importance whether the addressee of the enforcement notice owns the polluted premises. If more than one polluter is involved in pollution, a compliance order must be given to all of them. The authority, which has conducted a cleaning up, may sue the responsible persons and businesses for the costs of remedying environmental contamina-tion.

If the addressee of the enforcement notice cannot freely dispose of the polluted premises, the authorities must give an enforcement notice to the person who can dispose of the real estate. He can be ordered to tolerate that cleaning up or other measures are taken at the cost of the polluter.

The enforcement notice must be registered on the real estate at the expenses of the addressee of the order. Enforcement notices concerning the operation of a business must be binding also to future entrepreneurs. An enforcement notice cannot be given if 30 years or more have elapsed from the time of ceasing of the activity, which caused the pollution.

Mapping of contaminated sites
As a consequence of the Soil Contamination Act, a new system of mapping of contamination is introduced. According to the act, the county council shall carry out mapping, possible through technical investigations, of contaminated areas in co-operation with the municipal council.

A site is mapped if it is contaminated or if it is highly probable that the site contains soil contamination that may have a harmful impact to humans and the environment. The information on the mapped sites is entered into the Land Register.

A guideline on Mapping of Contaminated Sites has been issued in 2000. It will provide a detailed description of the mapping procedures for contaminated sites and sites supposed to be affected by present or former uses or vicinity to other pollution sources.

Approval, obligation of notification, obligation to act, etc.
According to the definitions in the appendix to chapter 5 in the Environmental Protection Act, some activities need prior approval or permit before they can be carried out. Environmental and/or health related norms are typically laid down in approvals or permits to carry out a certain activity.

Some activities are permitted if they have been notified in advance - they do not need prior approval as such.

For some activities the entrepreneur shall notify the authorities if there is a risk for serious damage on environment or health.

Restrictions on land-use
Owners of sites mapped as contaminated (or potentially contaminated) are subjected to a number of restrictions on land use. Before initiating building or construction work on the site, an application should be sent to the regional council. A permit will often be given on the condition that the owner or user carries out the required pollution investigations on his own account. Building or construction permits relating to contaminated soil are not required for mapped industrial sites, if the use of the site is not changed. However, the municipal authorities must be notified if soil is removed from the site.

People who live in slightly contaminated areas will receive advice on soil-exposure reduction measures. A guideline "Advice to residents in slightly contaminated areas" has been issued in 2000. In the case of areas that are accessible for the general public it is possible to give an enforcement notice to the owner on measures to secure that contact with contaminated soil is avoided.

6.4.2 Economic instruments

With respect to contaminated soil, special economic instruments do not play a key role in the regulation of behaviour aimed at preventing soil contamination. However, the principle of liability can be considered as such, given the economic consequences for any polluter if soil pollution occur.

Taxes are used in two cases:

Pesticide taxes
With the aim of reducing pesticide use mainly in agriculture and public and private cleaning of roads and gardens, pesticides are now subject to taxation.

For information about the Pesticide tax, refer to chapter 10.

The revenue of these taxes is funding a research programme for the environmental and health effects of pesticides.

Water fund
Some clean-ups can be financed through the Water Fund provided for in taxes on drinking water with the double aim of protecting the limited water resources by reducing the drinking water consumption and funding of remedial actions on contaminated borings and water abstraction zones.

The Oil Industry's Environmental Fund
In the wake of the energy crisis in 1973, a series of structural changes followed, take-overs, and rationalisations within the oil industry leading to close down of many petrol retail sites. In 1990, 6,000 retail sites had been closed down leaving an enormous remediation problem.

It was foreseen that enforcement notices to the owners could be in vain since no infringement of the environmental law had occurred, and which would involve the state to cover the expenses.

The amount of public money to be used for cleaning up contaminated soil was not large enough and consequently, the organisations of oil importers as well as retail dealers made in 1992 an agreement with the environmental authorities concerning voluntary clean-ups called "The Oil Industry's Environmental Fund". The goal of this fund is to finance efforts to clean-up contaminated petrol retail sites. It is clearly assumed that all companies, whether or not they had an interest in utilising the environmental fund, will be covered by the contract. The assumption is justified by the relationships in the industry that no company could tolerate unequal competition. The consumers pay for the soil clean-ups through a price increase of 0.05 DKK/l. This produces an annual budget for investigation and/or remediation of approximately 300 sites.

In total 9,660 retail sites have been notified for clean-ups by the Fund. Of these 2,200 have been cleaned up until 1 August 2000.

Programme for Development of Technology – Soil and Groundwater Contamination
In 1996, a programme for development of clean-up and remediation technologies relating to soil and groundwater contamination was set up primarily to stimulate the public authorities to apply innovative methods and replace standard excavation and replacement of contaminated soil.

Since the programme was launched, about 60 projects have been initiated, half of them to support testing of different remediation technologies. The other half supports development projects dealing with different remediation technologies, or enhances general knowledge on soil contamination.

Insurance scheme for oil tanks used for domestic heating
A special rule has been introduced regarding owners of oil tanks with a capacity below 6,000 litres, used for domestic heating. Strict liability in these cases only applies if contamination takes place after March 1, 2000. These more strict rules on the responsibility of owners of private oil tanks are combined with a compulsory insurance programme. All the oil companies supplying heating oil have established a joint insurance scheme. All owners of oil tanks used for domestic heating with a capacity below 6,000 litres are automatically covered by the insurance scheme.

For oil contamination, which is not covered by the scheme, the authorities can issue enforcement notices to the owner of the oil tank.

Land depreciation scheme for remediation of contaminated residential properties
Frequently, soil pollution in itself has not only environmental impacts, it also has financial consequences. One of the biggest economic problems relating to contaminated soil is the number of sites which are registered as contaminated and the loss it represents for the landowners.

A special clean-up system for landowners was introduced in 1993 with the Act on Economic Blight to Family Housing on Contaminated Land (The Loss of Value Act). After the enforcement of the Soil Contamination Act, this clean up system is continued within the Act under the title "The Land depreciation Scheme for House Owners". By paying a minor contribution, the landowner can initiate a publically financed clean-up.

An annual average of about 40 properties have been cleaned up under the scheme since 1994.

6.5 Actors

The primary actors concerning the regulation of soil contamination are listed in table 6.4. For general descriptions of the mentioned actors please refer to chapter 3.

Table 6.4 Actors, roles and responsibilities concerning soil contamination.

Actors	Roles and responsibilities concerning soil contamination
The Danish Environmental Protection Agency (DEPA)	DEPA administers in co-operation with the counties and the municipalities the legislation on contaminated soil, waste sites and landfills and supervises the counties and the municipalities work e.g. in connection with the counties and municipalities yearly reporting on activities, budgets and programmes. The DEPA provides guidance for the work of the regional and local authorities, initiate development of the administrative basis for the work of the counties and municipalities and initiate research and development. DEPA is responsible for the continuous elaboration and updating of the health based soil and drinking water quality criteria. The work is co-ordinated and supervised in a forum including representatives from the Ministry of Food, Agriculture and Fisheries, the Ministry of Health, and the Councils.
The medical officer on health	The medical officers on health play a central role locally concerning health aspects of contaminated soil where they advise counties and municipalities. They are in close contact with the central health and environmental authorities.
Counties	The counties are responsible for the provision of information on contaminated sites, mapping and for the remediation of orphan contaminated sites. Furthermore, the counties give permissions for voluntary clean-ups and changes in land use of contaminated sites. The counties are also responsible for the supervision of (potential) contamination occurring at some of the activities listed in the Environmental Protection Act and may give enforcement notices to polluters.
Municipalities	The municipalities are responsible for the supervision of (potential) contamination occurring at the majority of activities listed in the Environmental Protection Act and may give enforcement notices to polluters. The municipalities give instructions on disposal of contaminated soil.
Landowners	According to the law, the private and public landowner will be held liable to any contamination on his own property as well as contamination on other properties caused by him.
Public landowners	Several public landowners have set up programmes for clean-ups of contaminated areas following the rules for voluntary remediation. In some cases, remediation will be undertaken in order to provide clean plots for development, in other cases to protect the groundwater. Examples are the Ministry of Defence and the Danish National Railway.

Actors	Roles and responsibilities concerning soil contamination
Oil Industry	The remediation of contaminated former filling station sites is undertaken by the Oil Industry's special fund called "The Oil Industry's Environmental Fund" (see section 6.4.2).
Private developers	Landowners or private developers may perform voluntary clean-ups. If nobody can be held liable for the contamination, the clean-up will be covered by public funds, but the time perspective for this may be long. Therefore voluntary clean-ups may be profitable. Approximately half of all investigations and remedial actions are undertaken on voluntary basis.

6.6 Evaluation

The health-based regulation of soil contamination in Denmark has the objective to avoid any harmful impact on public health. In order to fulfil this objective the choice of risk assessment procedure and procedures for the derivation of health based soil quality criteria has been made considering the precautionary principle. Hence, the soil quality criteria are directed towards protection of the most vulnerable target group: Small children.

Except for a fatal case of explosion of landfill gas there are no recognised chases of harmful impact of soil contamination on public health. A great effort is invested in mapping of contaminated sites and in remediation and/or exposure prevention once contamination is recognised, following the above principles. However, there is a time lag before all potentially contaminated sites are investigated and human exposure prevented, and new contamination cases will eventually appear. Mapping of contamination from diffuse sources is furthermore by nature more difficult, especially in urban areas, but also in agricultural soils (e.g. originating from soil treatments with pesticides, fertilisers or waste products). Therefore it is possible that some human exposure occur above the levels set out in the regulation, but this risk is minimised by the mapping priorities, starting with sites with the most sensitive land-use such as residential use, childcare institutions or public playgrounds or sites where groundwater is threatened. Furthermore, limited exceeding of the soil quality criteria is not considered to endanger human health, but should rather be considered as an undesired reduction in safety margin.

Important challenges are therefore to optimise the mapping and remediation with respect to human health and groundwater protection also taking diffuse contamination into account. Risk communication is also an important tool in minimising human exposure and the sense of insecurity that may follow. Furthermore, prevention of new soil contamination is a prime issue in establishment of new installations and in control of the existing.

New health related issues concerning soil contamination will inevitably occur in the future, related to new sources of contamination or new knowledge of human health effects of chemicals. Another trend to be aware of is the increasing use of waste products as fertilisers on agricultural soils, which will introduce a broad spectrum of chemicals to the soil of which we do not presently know enough about fate and possible human effects.

Based on our present knowledge, the regulation in broad terms seems to be sufficient to obtain the objective of preventing harmful impacts on public health.

It is important to gain new knowledge on remediation techniques and exposure prevention in order to optimise the use of the economic resources. Also more knowledge on fate, mobility, bio-availability and human effects of chemicals from soil contamination are needed in order to confirm and secure the high level of protection.

6.7 References

Literature

DEPA (1998): "*Remediation of contaminated sites, guideline no. 6*".

DEPA (1995): "*Toxicological quality criteria for soil and groundwater, report no. 12*".

DEPA (2000): "*Advice to residents in slightly contaminated areas, guideline no 7/2000*".

DEPA (2000): "*Mapping of contaminated areas, guideline (draft)/2000*".

Danish legislation

Act no. 370 of 2 June 1999 on Soil Contamination.

Act no. 256 of 12 June 2000 amending the act on Chemical Substances and Products.

Act no. 698 of 22 September 1998 on Environmental Protection

Statutory Order no. 39 of 20 January 2000 on use of ash from gasification and combustion of biomass and biomass waste for agricultural and related purposes (the "Statutory Order on bioash")

Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes (the "Statutory Order on Sludge")

Statutory Order no. 829 of 24 October 1999 on application, establishment and operation of oil tanks, tubing and pipelines.

Statutory Order no. 241 of 27 April 1998 on Pesticides (with revisions of 20 December 1998, 25 September 1999 and 5 May 2000).

The Food Directorate's Statutory Order no. 659 of 14 July 1997 on maximum residue levels of pesticides.

EU legislation

Directive 86/278/EEC (1986): "*On protection of the environment, especially the soil, in connection with use of sludge from wastewater treatment plants for agricultural purposes*".

7 Drinking Water

In Denmark approximately 99% of the drinking water supply is based on groundwater. A protected groundwater resource free of contaminants and attractive to drink is therefore essential to the general health of the entire population.

The utilisation of groundwater is subject to a number of limitations, quantitative as well as qualitative. Quantitative limitations are those considerations that must be given to other water supplies, watercourses, wetlands etc. Qualitative limitations are induced in part by natural conditions such as salt water in coastal areas and mineralised water from certain geological strata. They are, however, also to a significant degree induced by the impact of pollution from the surface and extraction induced deterioration of water quality, e.g. from excessive extraction.

Thus environmental factors of the water media cover naturally occurring elements, pathogenic agents and anthropogenic substances. The concentration levels in tapped water will determine the degree of exposure to humans. This chapter will focus on the protection of human health reflected in the regulations and administrative practices connected with drinking water.

7.1 Human exposure to environmental factors

7.1.1 Environmental factors

The primary factors of concern are summarised in table 7.1.

Table 7.1 Summary of the origin, characteristics and potential health impacts of some critical drinking water pollutants.

Environmental factor	Origin and characteristics	Potential health impact
Nitrate	Agriculture. Diffuse impact on groundwater via application to crops	Acute toxic Induction of methemoglobinemia (reduced capability of hemoglobin to carry oxygen) especially in infants
Pesticides and metabolites	Use of pesticides in agriculture and cities. Point and diffuse sources from use, spillage and runoff in farmyards etc. and from application to crops. Use, spillage and runoff in public and private areas (parking spaces, along roads and railroads).	Acute toxic Neurotoxic Suspected carcinogens Reproductive toxicity.

Environmental factor	Origin and characteristics	Potential health impact
Aromatics	Urban areas primarily. Point source from present activities (industry, gas stations etc.) and former activities (e.g. old industrial sites). Aromatic compounds in motor fuels formed during oil refining. Leakage from fuel storage and handling, and spillages related to the production of glues, paints, solvents etc.	Known human carcinogen (benzene) Neurotoxic Odour/taste at low levels
MTBE (Methyl-tertiary-butyl-ether)	Additive in petrol. Spills and leakage from petrol stations	Possible carcinogenic potential at high doses Odour/taste at low levels
Chlorinated solvents (tetrachloroethylene, tetrachloromethane, 1,1,1 trichloroethane, trichloroethylene)	Urban areas. Point sources, primarily older industrial sites. Used for degreasing in metal manufacturing processes and for dry-cleaning. Also used in some tanning activities, paint production etc.	Neurotoxic Suspected carcinogens.
Metals		
Nickel	From oxygenation of pyrite by lowering of water table or by pollutants like nitrate in pyrite rich sediments	Ni allergy
Copper	From copper piping	Gastrointestinal effects
Lead	From installations	Neurotoxic effects (see chap. 6)
Bacteria, (examples) E.coli Camphylobacter Other bacteria	Contamination of borings, tanks and network.	Gastro-intestinal symptoms, diarrhoea, vomiting
Viruses, (examples) Enterovirus Hepatitis A virus		Diarrhoea, fever, vomiting and abdominal pains Hepatitis
Protozoans, (examples) Giardia intestinalis (doudenalis) Cryptosporidium parvum		Diarrhoea Abdominal pains

In addition, the Legionella bacteria, which are common in hot water systems, may grow in heated water and cause infection by inhalation of aerosols during showering. This may lead to Legionellosis or Pontiac fever. Especially complex and branched hot water systems may give high residence times and temperatures between 30 and 40 °C, which favours the growth of the bacteria.

7.1.2 Sources of pollutants

The sources of environmental factors in *groundwater* in Denmark posing a potential exposure risk represent three sources:

- Point source pollution
- Diffuse source pollution, and
- Extraction induced contamination

The sources of environmental factors in *drinking water* (treated groundwater) posing a temporary exposure risk in addition to the above mentioned are:

- Contamination at the water supply plant
- Bacterial contamination in the borings, tanks and supply network
- Contamination by accidental overflowing of wastewater into the water supply network.

Point source pollution

- Point source pollution defines a source of limited aerial expanse, but typically with a higher contaminant load per aerial unit than diffuse source pollution
- Municipal waste landfills and nationally controlled toxic waste landfills
- Industrial sites and chemical dumps
- Oil and petrol tanks etc.
- Leaking sewer systems

Of these point sources, old industrial sites and non-secure chemical waste dumps are generally considered to pose the greatest threat to groundwater quality. Contamination is often difficult to handle, not least because of the varying composition of the initial chemical products which, depending on the geochemical environment, follow a variety of paths of decomposition before entering the aquifers. Examples of major contaminants from the most widespread former industries are:

- Gasworks and asphalt industry: Phenols, cyanide and volatile aromates
- Paint, varnish, metal industry and dry-cleaning: Chlorinated solvents
- Lumber (wood), tanning and galvanisation industry: Heavy metals

Within the group of organic micro-pollutants, chlorinated hydrocarbons, aromatic hydrocarbons and phenols have been found in 21, 14 and 8% respectively of 3,565 sampled water supply borings around the country (GEUS, 2000). As far as heavy metals are concerned, only nickel is found in any significant percentage: 4.3% of 7,940 water supply borings. The origin of nickel is naturally occurring. Nickel in sediments is not a result of industrial point source impact (see below).

Diffuse source pollution

Diffuse source pollution relates to the application in agriculture of fertilisers and pesticides to soil and crops and risk of contamination of the groundwater resource.

Increased nitrate levels in groundwater in Denmark were recognised as a threat to water quality around 1980. As a result resources were invested in research to improve our understanding of the cause-effect relationships concerning nitrate contamination. This combined with an increasing media and political awareness of the problem as well as the incentive the EU nitrate directive provided, were some of the main instruments in paving the way for present day regulations. These notably include the county authorities' prioritisation of drinking water areas and associated legislative restrictions regarding land use. Drinking water areas are those areas where main infiltration to the drinking water reservoir takes place or are assessed as future infiltration areas (see section 7.4.1).

Nitrate has been found above the guide level of 25 mg nitrate/l in 9% of water supply borings in Denmark and 3% above the maximum admissible concentration of 50 mg nitrate/l.

Pesticide contamination of groundwater has become a major water quality issue during the 90s. The conjunctive development of better analytical instrumentation improving detection limits and increased sampling and analyses substantiated the threat pesticides posed and still pose to water quality. Partly as a result of this, the DEPA instigated the out-phasing and imposing of strong limitations on many of the pesticides detected in drinking water, a second updated pesticide action plan has been published (Pesticide Action Plan II, 2000) and the Danish Agricultural Advisor Centre has recently promoted "best practices for handling pesticides". Overall, the quantities of active compounds have been lowered as has the total spraying frequency. Intensive research in this field is on going with the aim of quantifying the threat of pesticides to water quality.

Pesticides and degradation products have been found in 23% of 5,643 sampled water supply borings. The maximum admissible concentration of 0.1 µg/l was exceeded in 9% of the borings.

In Denmark, the health impact of occupational exposure to pesticides has been documented. However, the impact on public health from pesticides and nitrate or other chemical pollutants in drinking water has not been investigated.

Extraction induced contamination
Extraction of groundwater may due to proximity of mineralised groundwater near to a freshwater resource cause influx of salts and contamination of the water resource. Lowering of the groundwater table around a well has in some cases caused contamination of the freshwater by Ni contaminated infiltration due to geochemical processes and leaching in near surface sediments.

Bacterial and chemical contamination in the water supply network
The dimension of pipes in the supply network combined with the speed of flow of water, are the primary controlling factors on the treated waters residence time in the pipes. Despite proper treatment at the waterworks even a very small bacterial content in the water might induce a water quality problem due to excessive residence time in the network, especially if cold and hot water pipes are placed close together. Long residence time may also imply release of chemical contaminants from the water pipes. Problems with contaminants originating from long residence times in water pipes in the individual houses may be minimised by letting the water run until cool before tapping for drinking purposes.

Flow of wastewater into the water supply network
Accidental spillage or flow of wastewater has in a few cases temporarily contaminated small town water supplies. The most serious example in Denmark

concerned a major outbreak of gastroenteritis affecting about 1,600 people in a small Danish town in the winter of 1991. The outbreak was caused by a congested municipal sewer and by technical defects in a privately owned waterworks. In another case, in 1997, a small river flooded the area around the local water works and the river water containing some sewage had entered the clean water tank. Up to 900 persons may have been affected by gastroenteritis due to contamination. In water resource planning there is accordingly high awareness of the of risk of contamination of drinking water, and wastewater contamination of drinking water is very seldom in Danish water supply.

In the period 1992-97 16 episodes with microbiological contamination of drinking water were been reported in Denmark. 23,000 persons have been exposed and approximately 6,400 cases of decease have been reported. Only in few episodes, the actual cause of contamination was identified. Probably even more cases have occurred without being reported.

7.1.3 Human exposure

The way of influence from substances injurious to health in drinking water is by direct exposure from contaminated drinking water contaminated with substances present in concentrations that pose a health risk. The various sources of contamination are outlined above. Apart from microbiological impact from wastewater contamination the only documented cases of impacts on human health directly related to drinking water concern a few cases of Ni-allergy, where the source could be traced back to anomalous Ni concentrations in drinking water (extraction induced contamination, see above).

The regular monitoring of raw water and drinking water quality as an integrated and high priority issue in Danish water supply should be emphasised in this context as it enables rapid and focused response to deterioration in water quality. Thus, although there are finds of pesticides, organic micro pollutants etc. in water supply borings the persistent focus on water quality by local and regional authorities ensures that contaminated borings and well fields are temporarily or even completely shut down if there is suspicion of human health impacts. There a number of examples of aborted borings especially in and around urban areas. In some cases extraction of groundwater from borings and well fields is maintained for remediation purposes to stop spreading of polluted groundwater to other well fields.

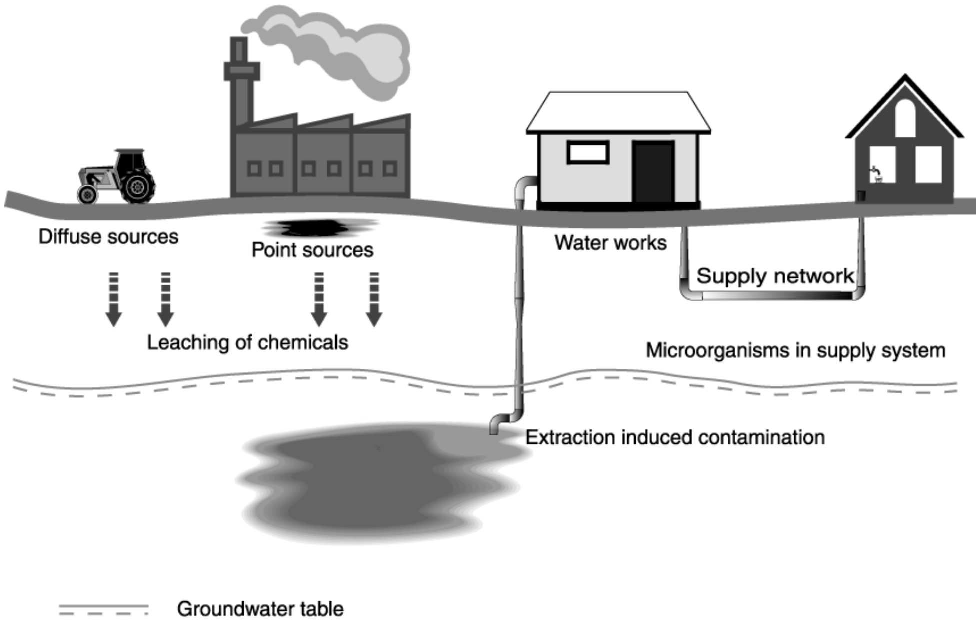


Figure 7.1 Ways of human exposure to environmental factors in drinking water.

7.2 Level of protection

7.2.1 Quality criteria/norms

For the guidance of public authorities, the Minister for the Environment and Energy has laid down provisions as to the quality of drinking water. These include both quality standards claimed by the EU directive on drinking water (98/83/EEC) as well as nationally derived quality criteria for other frequently identified substances. (See Appendix 4 containing a national draft list of drinking water standards according to dir. 98/83/EC and a national assessment of relevant drinking water quality criteria (not yet adopted). Methods and principles for conduct of health assessment and derivation of drinking water quality criteria are presented in appendix 1).

Generally, the drinking water quality criteria and drinking water standards are set at a level, which is considered to reflect a high standard as consumption of the drinking water should be healthy for the population. Furthermore, the water should visually appear clean and be without any unwanted taste or odour.

This applies for instance for pesticides (including biocides) following EU standards, which determine the limit value for the content of pesticides in drinking water to 0,1 µg per substance and 0,5 µg for the total of pesticides.

With respect to soil contamination in relation to groundwater, the objective is to protect groundwater as a resource, irrespective of whether abstraction borings are located in the area or not. Risk assessment procedures are described in section 6.2.1. The assessment of groundwater quality criteria is based on quality standards and criteria for drinking water, as groundwater, after ordinary water treatment processes, must fulfil the requirements for drinking water quality.

7.3 Regulation and strategy

7.3.1 Objectives and principles

Groundwater constitutes approximately 99% of the drinking water resource in Denmark and has always been regarded as a high quality water resource - also when measured on an international scale. However, from 1980 and onwards awareness grew among the authorities that the main drinking water resource in Denmark - groundwater - was under increasing threat of contamination from human activities related primarily to industry and agriculture.

The objective of the regulation for groundwater protection is thus, to ensure that the drinking water resource is protected and remains protected from activities and impacts posing a threat to the quality of our main water resource. Cleaning of groundwater for drinking water purposes is very seldom used in Denmark.

The present day regulation for the protection of the drinking water resource in Denmark is given by the Water Supply Act, The Soil Protection Act and the Environmental Protection Act and associated Statutory Orders from the Ministry of the Environment and Energy.

In this context, the international protocol on water and health adopted in London in 1999 should be mentioned. According to the Protocol the water resources shall be protected by establishing targets and by development of national or local action plans in order to avoid negative effects from pollution and different forms of land-use.

7.3.2 Legislation on drinking water protection

The Water Supply Act

The original Water Supply Act from 1978 focused primarily on regulations related to licences to abstract ground water, duties of the license holder, agreements on real property etc. The revision to the Water Supply Act, passed by the Danish Parliament 26 June 1998, contains a major addition concerning mapping of the groundwater resource, vulnerability assessments and planning of groundwater protection.

Section 3 of the revised The Water Supply Act (No. 479 of 1st July 1998) specifically focuses on the protection of groundwater resources and regulates water resource planning with the objective of ensuring:

- That exploitation and protection of water resources is based on an overall planning of utilisation of water resources taking into consideration:
  - the population and industries requirements for a sufficient water supply with a satisfactory water quality
  - protection of nature and environment in general
  - utilisation of mineral resources

- A co-ordinated water supply enhancing a rational utilisation of water resources

- A controlled expansion and maintenance of a sufficient and satisfactory water supply

A key element in the Act is the designation of drinking water areas in which main infiltration to the groundwater reservoir takes place, as mentioned previously and elaborated in section 7.4.1. Within such areas detailed mapping and investigation shall identify areas vulnerable to specific contaminants, e.g. nitrate. Areas identified shall be subject to an assessment comprising a detailed mapping of land use, pollution threats and the natural protection of the groundwater resource.

The resulting action plan shall describe the need for action concerning possible restrictions in land use and other human activities. It is within the jurisdiction of the regional and municipal authorities to seek agreements with landowners based on the action plan for regulating agricultural practices, purchase of property etc. The act includes regulations for the compensation of landowners by the negotiating party for loss of income, sale of land or property. The negotiating party may be the county, municipality, local water supply or combination of these.

Statutory order on Water Quality
The need for establishing formal water quality criteria was reflected in a statutory order on water quality in 1980 in which maximum permissible concentrations for a number of constituents in water were stated. The order was revised and replaced by the statutory order no.515 of 29 August 1988 on "Water quality and supervision of waterworks". The values and limits in this order are in accordance with the EU-directive 80/778/EEC on water quality.

Guidelines for Water quality and supervision of water supplies
The Danish EPA has issued guidelines (no.3, 1990) for the municipal authorities monitoring of drinking water quality and supervision of water supplies as an amendment to Statutory order no.515 mentioned above. The background for the guidelines is that water supply from especially private borings supplying a single household and to a lesser degree private water works often produce water of poor quality. Reasons for this are in part deficient technical installations and the borings location relative to pollution sources.

The objective of the guidelines is to strengthen the procedures for water quality by increasing the local authorities' options for detecting deterioration in water quality and addressing the problem at an early stage. It is also the objective to improve the supervision of the effectiveness of water treatment.

Guidelines for water quality monitoring
The Danish EPA has in 1997 issued supplementary guidelines (no. 2 1997) for the monitoring of drinking water quality with special emphasis on detailed analytical programmes for larger municipal water supplies producing more than 700,000 m^3/year.

The Planning Act
The Planning Act no. 388 of 6 June 1991 includes the regulation on the environmental impact assessment of activities that may pose a pollution threat to various media including groundwater.

The Planning Act has as one of its overall objectives to ensure a balanced development of the Danish society through concurrent planning on the national and regional level. Planning activities shall be undertaken with due consideration to valuable historic, cultural and natural values of the country and shall prevent pollution of air, soil and groundwater.

The latest revision of the act passed in 1999 (no.551 of 28 June 1999) includes legislation in accordance with the revision of the EU directive 85/337/EEC from 3 March 1997 (97/11/EEC) concerning the environmental impact assessment of various activities on the environment. Planned new activities in drinking water areas covered by this legislation shall therefore be subject to an impact assessment of the activity pollution threat to the drinking water resource.

The Soil Contamination Act

The increasing awareness by authorities that landfills with various wastes presented a threat to groundwater quality led to a revision of the Chemical waste deposit Act of 1983 resulting in The Waste deposit Act of 1990, which in 2000 was replaced by the Soil Contamination Act, which has a much broader perspective. The primary objective of this legislation is to prevent, eliminate or reduce soil contamination to hinder harmful impact of soil contamination to groundwater, human health and the general environment. Reference is given to chapter 6 on the soil media.

The Environmental Protection Act

The Environmental Protection Act focuses in terms of groundwater protection on the responsibility of owners of industrial, agricultural activities as well as land- and property owners in general to ensure that their activities do not give rise to a pollution threat to groundwater. Owners shall comply with the regulations given in the law administered by the local, regional or national authorities.

- Private and public owners of industrial, agricultural and other activities which are listed under Art. 35 of chapter 5 of the Danish Environmental Protection Act shall comply with the regulations set by this Act for minimising any pollution threat to soil and groundwater from human activities.

Owners of such activities as included above shall comply with recommendations by authorities (local, regional or national) either in the planning of an activity or as a result of inspection from an on-going activity. The activity shall consequently meet the requirements of the Environmental Protection Act, Chapter 3 concerning protection of soil and groundwater. The section states that compounds, products and materials that may pollute the groundwater, soil and subsoil shall - unless permitted otherwise:

- not be disposed in unauthorised dumps
- not be deposited or stored on the soil surface, or
- not be disposed to the subsoil

Statutory order on manure

Statutory Order no. 877 from 10 December 1998 from the Ministry of the Environment provides specific limits for production and use of manure for fertilising crops on a farming unit. The limits relate directly to the type and number of livestock. The statutory order is in accordance with the Nitrate directive (91/676/EEC).

7.4 Instruments

This section describes the legal, administrative and economic instruments that exist within the Danish Environmental legislation for groundwater protection.

7.4.1 Regulatory instruments

Norms

For the guidance of public authorities the Minister for the Environment and Energy may lay down provisions as to the quality of drinking water.

Quality standards for drinking water are in accordance with the EU-directive on drinking water quality. The directive provides the minimum requirements to drinking water quality (see Appendix 4) and national legislation may set more stringent standards for drinking water quality. Health based drinking water quality criteria for additional substances are derived on a national basis (Appendix 1).

Only few specific groundwater quality criteria have been derived. Normally drinking water quality criteria are used in the assessment of groundwater, which must fulfil drinking water standards after ordinary water treatment. In Denmark, this comprises aeration and filtration.

Guidelines have been issued by the Danish EPA for risk assessment of chemical substances in drinking water (DEPA, 1992).

Furthermore, the Danish EPA has published health based drinking water quality criteria for several compounds and groups of compounds e.g. heavy metals, cyanides and phenols (DEPA, 1995). Appendix 1 provides a description of the methods and principles behind health assessment and derivation of drinking water quality criteria together with an overview of the present drinking water quality criteria.

Monitoring

Monitoring of the groundwater resource on a national scale was implemented following the approval by parliament of the Action Plan Aquatic Environment in 1987. The monitoring programme is based on wells located in 67 local areas evenly distributed across the country typically with 10 - 15 wells within each area. Furthermore, water analyses from agricultural water sheds and water supply wells are integrated in the monitoring programme.

The wells are sampled on a yearly basis for analyses of standard water quality parameters (naturally occurring components and physical-chemical indicators such as pH, taste), bacteriological analyses, inorganic traces, organic micro pollutants and pesticides). The monitoring programme enables the Geological Survey of Denmark and Greenland to provide the authorities and public with an annual overview of the state of the drinking water resource and thus also the scientific base for political initiative if so required.

Enforcement notices to the polluter

Danish environmental legislation is based on the polluter pays principle. The liability for soil contamination can be considered as both a regulatory and an economic instrument.

The Soil Contamination Act defines a set of rules on administrative orders to the polluter. An order on cleaning up pollution can be given by the municipal or county authority.

The concrete order concerning the cleaning up of such pollution is given to the polluter, and this order can be given irrespective of how the pollution has happened. It is furthermore without importance whether the addressee of the order owns the polluted premises. If more than one polluter is involved in pollution, a compliance order must be given to all of them. The authority, which has conducted a cleaning up, may sue the responsible persons and businesses for the costs of remedying environmental contamination. For further detail, please refer to chapter 6.

Restrictions on land use

Within drinking water areas are designated as vulnerable to nitrate, the Minister for the Environment may impose restrictions on requests for increasing livestock that can increase the risk for contamination of groundwater and surface water.

The Minister may also impose restrictions on the amount of manure that may be applied for agricultural use.

Planning instruments

The primary objective of the regulation is to prevent deterioration of the groundwater quality, and for this purpose planning instruments are of primary importance.

Designation of drinking water areas

The Danish counties have designated areas with special drinking water interests, which cover 35% of the country. Remaining areas have been designated as valuable water abstraction areas and areas with restricted water abstraction interests. The latter constitute a minor percentage of the designated areas and are largely located along some coastal areas and urban industrial centres. The designated areas play a key role in the prioritisation of contaminated sites for investigation and remediation.

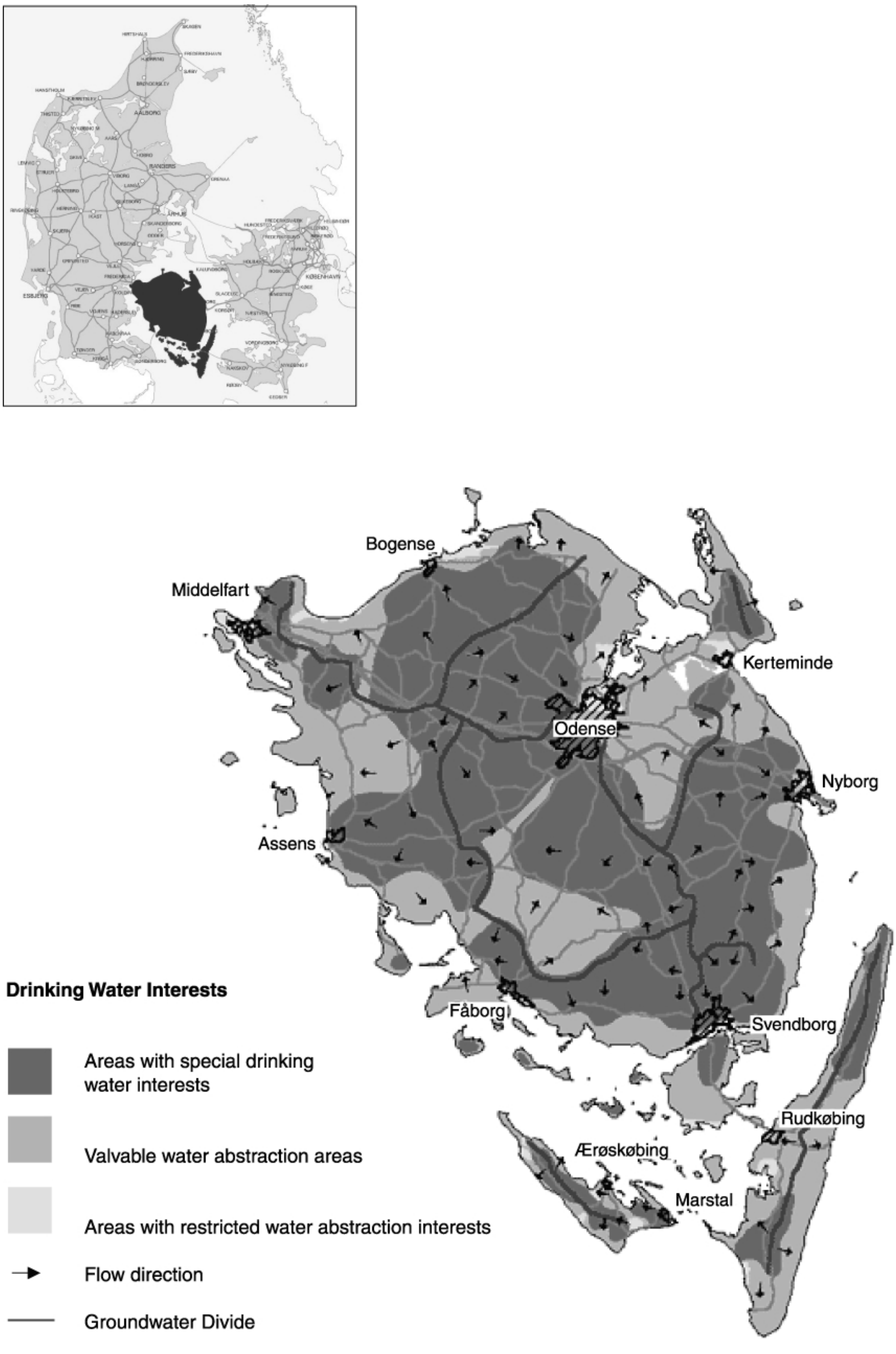


Figure 7.2 Designated areas with water abstraction interests on Funen.

Point sources

According to the Soil Contamination Act, the county council shall carry out mapping, possible through technical investigations, of contaminated areas in co-operation with the municipal council (see chapter 6).

Diffuse sources
Following the passing of the revised Water Supply Act in 1998 the counties initiated vulnerability mapping of the drinking water resource. This comprises both basic hydrogeological mapping and compound specific mapping initially with respect to nitrate but also pesticides in the near future.
The objective of the hydrogeological mapping is to provide a technically solid framework in terms of understanding of infiltration, geology, groundwater flow etc. for the vulnerability mapping.

Environmental agreements
With the increasing focus on groundwater protection and reduction of diffuse source impact from nitrate especially at present, the counties and municipalities have the option to negotiate environmental agreements regarding land use and agricultural practices and offer economic compensation for loss of income. This is the recommended approach and clearly preferable to non-negotiable law enforcement and expropriation.

7.4.2 Economic instruments

Taxes are used in two cases:

Water Charges
The revised Water Supply Act from 1998 enables counties - who are responsible for the assessment, protection and management of the drinking water resource - to finance these activities by putting a fee on water abstraction. Any water abstraction within a county is based on a permit by that county in which the maximum limit of groundwater extracted per year is stated. The charge is calculated per m3, based on the maximum permitted water extraction irrespective of weather the owner of the well or borings actually extracts groundwater up to this limit. For permits for water extraction for industry and agriculture, e.g. water for cooling or irrigation of crops, the fee is based on 1/3 of the maximum permitted water extraction / year.

This charge is, in addition to the standard fee, paid by households and others in Denmark for water consumption, also paid per m^3 water consumed.

Pesticide taxes
With the aim of reducing pesticide use in agriculture and public and private cleaning of roads and gardens, taxes have been put on pesticides.

The revenue of these taxes is funding a research programme for the environmental and health effects of pesticides.

The Water Fund
For private water works with a yearly abstraction below 80.000 m^3/year the National Water Fund enables these water works to apply for funding of vulnerability assessments within the catchment area of the water works as well as for other purposes.

Some clean-ups can also be financed through the Water Fund with the double aim of protecting the scarce water resources by reducing the drinking water consumption and funding of remedial actions on contaminated borings and water abstraction zones.

Programme for Development of Technology – Soil and Groundwater Contamination
In 1996, a programme for the development of clean-up and remediation technologies relating to soil and groundwater contamination was set up primarily to stimulate the public authorities to advocate innovative methods and replace standard excavation and replacement of contaminated soil (see further information in section 6.4.2.

7.5 Actors

Water supply in Denmark is decentralised and based on both public and private water supply. All water supplies are covered by the Water Supply Act passed by the Parliament and administered by the state authorities. Management of the water resource and water supply is the responsibility of the counties and municipalities.

The primary actors concerning regulation of groundwater contamination are listed in table 7.2. For general descriptions of the mentioned actors please refer to chapter 3.

Table 7.2 Actors, roles and responsibilities concerning groundwater contamination.

Actors	Roles and responsibilities concerning Groundwater contamination
The Danish Environmental Protection Agency (DEPA)	DEPA administers the legislation on water resource planning and provides guidance for the work of the regional and local authorities and supports research and development. DEPA is responsible for the continuous elaboration of health based drinking water quality criteria. The work is carried out in collaboration with representatives from the Ministry of Health and the Ministry of Food, Agriculture and Fisheries.
The Geological Survey of Denmark and the Danish Technical University.	Research in groundwater and groundwater pollution and development of tools and methodologies for water resource planning is concentrated most notably within the Geological Survey of Denmark and the Danish Technical University.
Counties	According to the Water Supply Act , the counties are responsible for ensuring a sufficient water resource of a satisfactory quality and implementing those measures necessary to meet these requirements. The county authorities are responsible for handling applications for water abstraction exceeding 3,000 m^3/year. The county authorities shall in understanding with the municipal councils, undertake water resource assessment and planning, mapping, vulnerability assessment and action planning for protection of the water resource.
Municipalities	The municipal authorities are responsible for the water supply and monitoring of the quality in the municipality including handling of applications for water extraction from private and public applicants (less than 3,000 m^3/year), supervision of public water works and planning and supervision of the supply network. The municipal council may propose and apply for the county councils approval of their own action plan for water resource protection should it find that the overall water resource planning conflicts with the best interests of the municipal and/or the municipal water supply.
The medical officer of health	With respect to drinking water, the municipal council shall consult the medical officer if there is any indication of deterioration in the water quality and suspicion of health effects for the local population. The municipal council may under the guidance of the health officer order a water supply shut down temporarily or in severe cases finally.
Public and private landowners	According to the Environmental Protection Act private and public landowners can be held liable to purposeful contamination on their property as well as contamination on other properties caused by activities under their ownership.

7.6 Evaluation

The objective of the drinking water regulation in Denmark is that the drinking water supply shall be based on unpolluted groundwater - tasteful, clear and free of smell. The consumer shall be able to drink it without worries of contamination. Therefore the protection of the groundwater resource has a very high priority, and the quality criteria set for groundwater are generally the same (or even lower) as for drinking water, which is basically following the EU directive on drinking water.
There are very good reasons for setting strict objectives for drinking water, as drinking water cannot easily be replaced by other choices of drink. We all need plenty of drinking water every day, for drinking and for cooking.

Health impacts caused by consumption of drinking water in Denmark are rare and generally the objectives of the regulation are obtained. However, health impacts do occur and most often as a disease caused by microbial contamination in the water supply network. Health impacts from chemical components in drinking water are only observed in a very few cases as nickel allergy (nickel from pyrite rich sediments) or methemoglobinemia caused by nitrate.

Furthermore, all contaminants in groundwater and drinking water are not known because the monitoring programmes only find those selected substances they are designed for. So other substances, that haven't yet been recognised as potential health factors, stay unattended. To our knowledge, no studies in Denmark have been made with respect to the evaluation of health effects from longterm exposure to low levels of contaminents in drinking water.

Another important characteristic is the delay between the origin of pollution and the occurrence of contaminants in the groundwater, not to say in the drinking water. The delay can be tens of years. Many contaminants are most likely on their way towards the groundwater and cannot be stopped by new regulation. A large number of drinking water abstraction borings have been aborted because of groundwater contamination from either point sources or diffuse sources, and this picture must be expected to continue. Today's regulation will in most cases first show results in many years.

One trend to observe in the regulation of drinking water is the increase in use of chemicals in society, chemicals of which we in many cases have limited knowledge. Some of these may end up in groundwater. Other trends are connected to the supply network in which new materials may be the source of chemical contaminants or microbial growth in drinking water. Water savings may give lower flow and hence longer residence time in water pipes, which increase concentrations of contaminants released from the materials of the supply network and may also increase the risk of microbial contamination.

One of the great challenges of regulation is therefore to foresee future contamination problems. In the light of the limited knowledge of many chemicals including their health effects and future occurrence in groundwater, the use of the precautionary principle in the regulation is obvious. Prevention of new contamination from both point sources and diffuse sources is very important. Especially the use of fertilisers (nitrate) and pesticides are in focus to day and should be also in the future. Another challenge is to design the monitoring programmes to give the best possible protection of public health.

Prevention of microbial contamination in the supply network by maintaining and developing strict standards for water supply networks must also be given priority as well as regulation of the materials used for the supply network.

The need for new knowledge is obvious concerning several items:

- Sources of groundwater pollutants, especially pesticides in rural areas.
- Fate of chemicals and micro-organisms in the soil and groundwater environment.
- Optimal design of groundwater and drinking water monitoring programmes.
- Prevention of microbial drinking water contaminations.
- Health effects of long term exposure to low concentrations of chemical contaminants in drinking water.
- Drinking water quality at the consumers tap, the influence of the distribution system on water quality
- Development of methods to predict/ rank chemicals, which may endanger the groundwater after intended or unintended release in the environment.

7.7 References

EU Legislation

Directive 80/778/EEC (1980): "*On the quality of water intended for human consumption*".

Directive 85/337/EEC (1985): "*Effects of certain public and private projects on the environment - EIA*".

Directive 91/676/EEC (1991): "*Concerning the protection of waters against pollution caused by nitrates from agricultural sources.*"

Council Directive 97/11/EEC (1997): "*Effects of certain public and private projects on environment (revision of Council Directive 85/337/EEC)*".

Council Directive 98/83/EEC (1998): "*On the quality of water intended for human consumption (revision of Council Directive 80/778/EEC)*".

Danish Legislation

The Water Supply Act : Act no. 299 of 8 June 1978.

The Planning Act: Act no. 388 of 6 June 1991.

The Soil Contamination Act: Act no. 370 of 2 June 1999 (replaces Act no. 420 of 13 June 1990).

The Environmental Protection Act: Act no. 358 of 6 June 1991.

Statutory Order no. 515 of 29 August 1988 on Water Quality and Supervision of Waterworks.

Statutory Order no. 877 of 10 December 1998 on Production and Use of Manure.

DEPA (1990): "*Guidelines for Monitoring of Drinking Water Quality and Supervision of Minor Water Supplies: Guideline from the DEPA no 3*".
DEPA (1992): "*Guidelines for Risk Assessment of Chemical Compounds in Drinking Water*" Guideline from the DEPA no 1.

GEUS, 2000: "*Groundwater monitoring. Geological Survey of Denmark and Greenland*".

Pesticide action plan II. The Ministry of the Environment and Energy, The Ministry of Foods, Agriculture and Fisheries, March 2000.

DEPA (1997): "*Monitoring of water quality at waterworks: Guidelines from the DEPA no.3*".

DEPA (1995): "*Toxicological quality criteria for soil and drinking water. Project no. 12 on soil and groundwater*".

8 Bathing Water – Coastal and Fresh-waters

Denmark has approximately 7,000 km of coastline and good beaches are common in all parts of the country. A large number of the population can reach the coast within 30 minutes and going to the beach, bathing or just enjoying the sea is an intricate part of life especially during the summer period. Lakes of a sufficiently good quality may also serve as bathing water during the summer. Good bathing water quality is therefore an important issue for a great deal of the population and the publications in local media by authorities on bathing water quality are followed with interest. Monitoring of bathing water quality along our coasts is essential as a number of sources e.g. sewage effluents, may threaten the water quality. The quality of bathing water has generally improved in Denmark, but nevertheless restrictions on bathing still have to be enforced due to local conditions, e.g. effluent from contaminated watercourses (overflow of untreated wastewater during heavy rain), discharges from scattered settlements in the countryside etc.

Both coastal and fresh waters may contain mixtures of pathogenic and non-pathogenic microbes derived from sewage effluents, from the population using the water, from farming activities, industrial activities (eg. slaughter-houses) and wild-life (birds) in addition to indigenous micro-organisms. Furthermore, the water quality may also be influenced by effluents of chemical substances from industrial and farming activities as well as deposition from airborne pollution and contaminants in rain.

Human exposure to the constituents of the bathing water media thus covers both pathogenic agents and man-made substances comprising the environmental factors for this media.

8.1 Human exposure to environmental factors

8.1.1 Environmental factors

The primary factors of concern are summarised in table 8.1.

Table 8.1 Summary of the origin, characteristics and health impacts of some critical pollutants.

Environmental factors - general	Origin and characteristics	Health Impact
Bacteria (examples) Coli, Enterococci, Salmonella, Campylobacter **Virus (examples)** Hepatitis A virus, Enterovirus **Protozoans (examples)** Cryptosporidium parvum Giardia intetinalis (duodenalis) **Algae** Blue-green algae	Sewage effluents to watercourses and coastal locations, micro-organisms of animal origin and people using the bathing water. Blooming of algae because of nutritional effluents and high temperature.	Gastro-intestinal symptoms Eyes, ears and respiratory symptoms Hepatitis Diarrhoea, vomiting, fever and abdominal pains Diarrhoea Headaches, skin irritation, fever, nausea and diarrhoea
Man-made organic substances. Examples are: Organic solvents Plastisicers (e.g. DEHP) Detergents (e.g. LAS,NPE) Complexing agents (EDTA, NTA) Polyaromatic hydrocarbons (PAH) Phenols	Sewage effluents, and to a minor degree industrial processes and farming activities.	Carcinogenic effects Reproductive toxicity Organ toxicity Acute toxicity

Abbreviations:

DEPH: bis (2-Ethylhexyl)phthalate
LAS: linear alkylbenzene sulphonate
NPE: nonylphenolethoxylate
EDTA: ethylenediaminitetraacetic acid
NTA: nitrilotriacetic acid
PAH: polycyclic aromatic hydrocarbon

8.1.2 Sources of pollutants

Environmental factors in bathing water in Denmark primarily originate from wastewater. The primary impact is by overflow of untreated wastewater during heavy rain, but also by run-off from rural areas and from scattered housing in the countryside not being connected to a wastewater treatment plant. Also incompletely treated wastewater or breakdowns at treatment plants may be sources of environmental factors.

Today approximately 130.000 private residences and 13.000 summerhouses discharge wastewater directly from a settling tank, which is virtually untreated with respect to micro-orgamisms. The wastewater is discharged to drains, ditches, watercourses, lakes and to the sea resulting in unhygienic conditions, especially in recipients with low water exchange.

In May 1997, the Danish Parliament agreed upon an action plan for improved wastewater treatment involving approximately 64.000 scattered settlements in the countryside. The actions will include connection to public wastewater treatment, local sand infiltration plants or small wastewater treatment plants. This action plan will contribute to improvement of the general water quality in rivers, lakes and coastal waters and thereby also contribute to improvements of the bathing water quality (please refer to chapter 12 for further details on wastewater).

Other sources may be the population using the bathing water, birds and other animals, truly indigenous micro-organisms and to a lesser degree also industrial processes and farming activities. The bathing water quality around outlets of water courses may be reduced because of impact from grassing animals. The indigenous micro-organisms of concern are blue-green algae that often bloom during summer when temperature is highest. The algae secrete toxins, but only in rare cases are the concentrations high enough to affect humans. In Denmark, there are no fatal cases of human intoxication by algae and no reported epidemics.

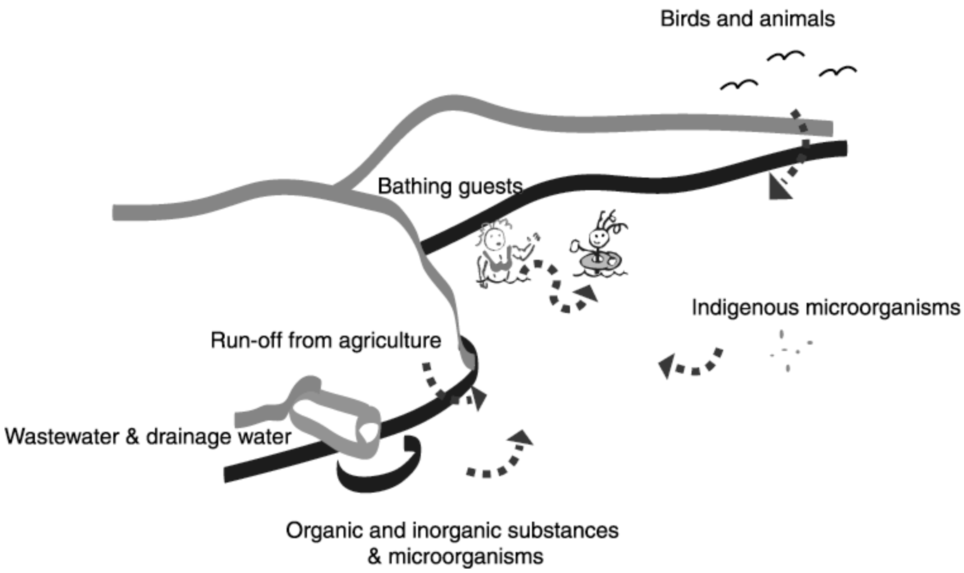


Figure 8.1 Ways of human exposure to environmental factors in bathing water.

8.1.3 Human exposure

The ways of influence from micro-organisms in bathing water are by direct exposure through ingestion of water during bathing and/or through breaks in the protective skin barrier from bathing water contaminated with micro-organisms present in concentrations and amounts that pose a health risk. Some of the various sources are outlined above.

Similarly, chemical substances in water (including toxins produced by bacteria or algae) may be ingested or taken up through the skin as well as directly affect the skin and mucous membranes in e.g. the eyes. In studies of the relationship between health impairment and micro-organisms in bathing water in the sea or lakes, it has been found that the rate of most symptoms is significantly related to the count of enterococci (faecal indicator bacteria). However, it is generally difficult to relate impacts on public health to exposures in bathing water, because there is no systematic registration hereof.

8.2 Level of Protection

Regular monitoring of bathing water based on faecal indicators is the key element of Danish regulation on bathing water quality to enable rapid response by authorities and protection of the population.

The indicator organisms considered (WHO 1998) to correlate best with health outcome are generally enterococci/*faecal streptococci* for both marine and freshwater and *E.coli* for freshwater. In Denmark thermotolerant coliform bacteria have been chosen as indicators for E.coli.

It should be noted however, that an evaluation prepared by the Danish Water Quality Institute and the Institute of Medical Microbiology, University of Aarhus for DEPA in 1995 suggests that there is a risk that the traditional indicators (faecal coliforms) may not accurately reflect the quality of water. Many viruses, bacteria, worms and worm eggs appear to be far more resistant than faecal coliforms. The absence of faecal coliforms does therefore not necessarily prove that pathogens are not present in the recipient. For these reasons the Danish monitoring programme, including the choice of indicator parameters (bacteria, viruses and/or protozoans), is presently under revision.

The EU-directive on the quality of bathing water (76/160/EU) is presently also under revision. The review of the directive is required as it is outdated and the new directive shall make reference to the water framework directive currently under preparation.

Also the blooming of blue-green algae are monitored, especially during summer where the water temperature is at its highest.

8.3 Regulation and strategy

The regulatory basis for monitoring bathing water quality in seawater and lakes is given by Statutory order no. 292 of 23 June 1983 on bathing water and beaches from the Ministry of Environment and Energy. The order is in accordance with the EU directive from 1976 on quality of bathing water (76/160/EU). The directive is a minimum requirement directive enabling national legislation to set more stringent requirements.

The order covers:

- Freshwater and seawater designated as bathing water in the county regional planning (each of the 14 counties shall in accordance with the Planning Act prepare a regional plan for the county every 4 years covering all aspects of county jurisdiction including bathing water and beaches)
- Freshwater and seawater where bathing is not prohibited.

The objective of the order is in compliance with the EU directive to ensure and maintain good water quality in areas of freshwater and seawater used for bathing.

Today the evaluation of the bathing water quality is based on the monitoring results from the previous year. Therefore, there is an obvious need for a revised system with possibilities for early warning of bathing guests based on continuous monitoring, characterisation of the bathing water site including identification of potential contamination sources, prediction of rain events that may lead to overflow of untreated wastewater etc.

8.4 Instruments

8.4.1 Regulatory instruments

Limit values
According to the present regulation (Statutory order no. 292 of 23 June 1983) bathing water in sea or lakes during the bathing season (1 June - 1 October) shall not contain more than 10,000 coliform bacteria pr. 100 ml, and not more than 1,000 thermotolerant coliform bacteria (faecal coli / E.coli) pr. 100 ml. A statistical methodology developed by the DEPA is applied to assess analytical results.
In addition, bathing water shall have no sensory impairments, e.g. discoloration, smell and poor visibility. It is a requirement that the acidity/ alkalinity of the bathing water (pH-value) lies within the interval of pH=6 - pH=9.

A minimum of 10 samples shall be taken for water quality analysis during the season, starting one month before the bathing season (1 June - 1 October). Samples shall be taken in areas normally used for bathing. The municipal and county authorities in conjunction decide precisely where and when the samples shall be taken.

The number of samples for analysis may be reduced from 10 to 5 if bathing water at a specific locality over 2 consecutive years has a composition and quality in accordance with quality criteria given above. If bathing water statistically has a significantly poorer quality than the above given criteria, the number of samples shall be increased to 20 per year.

Restrictions on bathing
Should the quality of bathing water in seawater and lakes fail to meet the quality criteria and show significant indications of deterioration, the municipal council shall in collaboration with the regional authorities and the medical health officer instigate further microbiological analysis of the bathing water.

If the water quality cannot immediately be improved it is the responsibility of the municipal authorities to forbid bathing. In such cases, the same authorities shall inform the public of restrictions concerning bathing in appropriate local media (e.g. newspapers) and also ensure that signs are placed up at the relevant bathing localities.

8.5 Actors

Monitoring and supervision of beaches and bathing water quality is the responsibility of the local and regional authorities.

The primary actors concerning regulation of the bathing water media are listed in table 8.2. For general descriptions of the mentioned actors please refer to chapter 3.

Table 8.2 Actors, roles and responsibilities concerning bathing water in sea and lakes:.

Actors	Roles and responsibilities concerning bathing water contamination
The Danish Environmental Protection Agency (DEPA)	DEPA is responsible for the preparing of draft acts and statutory orders and provides guidance for the work of the regional and local authorities. DEPA is responsible for sending the results of the bathing water quality monitoring to the Commission.
Counties	The county and municipal authorities are responsible for the legal administration and are therefore obliged to ensure that the quality objectives of the legislation can be met and also maintained.
Municipalities	The municipal authorities are responsible for the administration of the statutory orders e.g. supervising the quality of bathing water, monthly sampling and analysis, forwarding the analytical results to the county authorities and the medical officer on health etc.
The medical officer of health	With respect to bathing water, the medical officer shall be consulted by the municipal council if there is any indication of deterioration in water and suspicion of health effects for the local population. The municipal council may in agreement with the health officer and the county authorities forbid bathing.

8.6 Evaluation

The health objective of the bathing water regulation is to prevent bathing guests from getting ill when bathing in waters appointed as bathing waters – e.g. zero effect level. Instruments for obtaining the objective are the counties and municipalities planning activities, design of wastewater systems (location of outlets, dimensioning of retention basins etc.), discharge requirements (wastewater treatment plants, industries etc.), monitoring of bathing water quality and occasionally bathing restrictions if the water quality is insufficient, until improvements have been obtained.

There have been no recognised cases of negative health impacts from contaminated bathing waters in many years, and during the last ten years there has been a further reduction in wastewater impact on the water environment (improved wastewater cleaning technology, sharpened discharge requirements, dimensioning of retention basins to minimise overflow etc.). However, some bathing waters are still influenced by wastewater. The primary impact is by overflow of untreated wastewater during heavy rain, but also by run-off from rural areas and from scattered housing in the countryside not being connected to a wastewater treatment plant.

Systematic registration of water carried disease caused by bathing is not performed, and there is therefore no exact knowledge of the impact on bathing guests. Furthermore, man-made chemical substances are not included in the monitoring programmes and long-term health effects of chemical substances in bathing waters are not known. The microbial quality of bathing waters are monitored, but it is questionable whether the traditional bacterial indicators (faecal coliforms) accurately reflect the quality of the water e.g. the occurrence of more resistant micro-organisms such as viruses and protozoa. Therefore, the Danish monitoring programme is presently under revision also with respect to indicator parameters, monitoring frequency and the reaction time between monitoring result and regulatory action when needed.

Hence, among the challenges are improved monitoring with suitable indicators and limit values, but also continued decrease of outlet of untreated wastewater even though it is already very low compared on an international scale.

New knowledge is needed in many fields: Suitable indicators are needed for monitoring the microbial quality of bathing waters. More knowledge is needed about human exposure to and effects of microbiological and chemical environmental factors in bathing waters originating from untreated as well as from treated wastewater. Also more knowledge is required to assess the impact from run-off from pastures with grazing livestock. Furthermore there is a need for more knowledge about viruses and protozoan in recreational waters. Such knowledge is necessary for the design of the regulation of tomorrow.

8.7 References

Literature

DEPA (1995): "*Bathing Water - Microbiological Control. Report no. 314*".

DEPA (1985): "*Bathing Water Control, Guideline no. 2*"

WHO's Draft Guidelines for Safe Recreational Water Environments: Coastal and freshwaters.

Danish Legislation

Statuary Order no. 292 of 23 June 1983 on Bathing Water and Beaches.

EU Legislation

Directive 76/160/EEC (1976): "*Setting of quality standards for bathing water in the member states*".

Directive 85/337/EEC (1985): "*Effects of certain public and private projects on the environment - EIA*".

Directive 91/676/EEC (1991): "*Concerning the protection of waters against pollution caused by nitrates from agricultural sources*".

Directive 97/11/EEC (1997): "*Effects of certain public and private projects on environment (revision of Council Directive 85/337/EEC)*"

9 Swimming pools, spas and similar recreational water environments

All municipalities in Denmark have one or more swimming pools representing an important source of recreation as well as being used for training purposes, treatment for hospital patients and other uses.

In contrast to coastal and fresh waters, pool water is recirculated and disinfected. Disinfection is a process whereby pathogenic micro-organisms are removed or inactivated so that they represent no significant risks of infection. In Denmark, disinfection is performed with chlorine or hypochlorite, which are reactive chemicals. They react with organic and inorganic materials in the water and materials contributed by the swimmers, which include sweat, urine, soap residues, cosmetics etc. to form various disinfectant by-products (e.g. trihalomethanes).

The large number of visitors to swimming pools and the resulting load on the water in a confined space makes them potential sources of substances and micro-organisms harmful to health. Regular monitoring of the water quality in the swimming pools is therefore essential.

9.1 Human exposure to environmental factors

9.1.1 Environmental factors

The primary environmental factors are summarised in table 9.1

TABLE 9.1 SUMMARY OF THE ORIGIN, CHARACTERISTICS AND HEALTH IMPACTS OF SOME CRITICAL POLLUTANTS.

Environmental factors – general	Origin and characteristics	Health Impact
Bacteria (examples) Thermotolerant coliform bacteria, Enterococci, Salmonella, Campylobacter, Pseudomonas, Legionella **Protozoa** Giardia, Croptosporidium **Virus** Adenovirus, Hepatitis A virus, Enterovirus	Micro-organisms from people using the pool (e.g. coli, and other thermotolerant coliforms) or micro-organisms that has grown because of temperature conditions and insufficient disinfection (e.g. pseudomonas aeroginosa especially affecting skin, ears and eyes).	Gastro-intestinal symptoms Eyes, ears and respiratory symptoms Diahorrea Vomiting Skin irritation
Disinfectants	Agents used for disinfection of the pool water i.e. Chlorine or hypochlorite. Agents for cleaning of the surrounding facilities.	Irritation of conjunctiva, mucous membranes, skin and respiratory tract. Odour
Disinfectant by-products i.e. Trihalomethanes, haloacetic acid, haloacetic acids, haloacetonitriles, haloketones, chloral hydrate (trichloroacetaldehyde), chloropicrin (trichloronitromethane), cyanogen chloride, chlorate, chloramines	Reaction between disinfectants and organic and inorganic substances	Irritation of conjunctiva, mucous membranes, skin and respiratory tract. Odour.
Chemicals contributed by swimmers, i.e. Urea, ammonia, amino acids, creatinine, etc.	Nitrogen containing compounds released from sweat and urine.	Irritation of conjunctiva, mucous membranes, skin and respiratory tract. Odour

9.1.2 Sources of pollutants

In swimming pools both the number of visitors and the way the pools and surroundings are constructed and managed can increase the potential for harmful effects.

Faecally and non-faecally derived micro-organisms, which may lead to adverse health effects include bacteria, viruses, protozoa and fungi. Faecal contamination may be due to faeces released by swimmers or contaminated source water. Many of the outbreaks of illness related to swimming pools have occurred because disinfection was poorly or not applied (WHO 2000a).

Non-faecal human shedding (e.g., from mucus, saliva, skin) in the swimming pool, spa or similar recreational-water environments is a source of potential non-enteric pathogenic organisms. Infected users can directly contaminate pool or spa waters and the surfaces of objects or materials at a facility with sufficient numbers of primary pathogens (notably viruses or fungi), which can consequently lead to skin infections in other patrons who come in contact with the contaminated water or surfaces (WHO 2000a).

Chemicals found in pool water include those that are related to water treatment — both the chemical additives themselves and the by-products that are produced from chemical reactions between the additives (particularly the reactive disinfectants) and organic and inorganic materials in the raw water — and those that are contributed by the swimmers, which include soap residues, cosmetics, suntan oil, sweat and urine (WHO 2000b).

Many chemical by-products associated with disinfection of pool waters are produced at levels that are at least comparable to those produced in drinking-water disinfection. In fact, as initial and make-up water entering the pool has in most cases already undergone drinking-water treatment and contains disinfectant and by-products, and as typical pool waters are recycled and additional precursors and disinfectant are added, the levels of disinfectant by-products found in disinfected pool water could easily exceed drinking-water levels. (WHO 2000b).

9.1.3 Human exposure

The ways of influence from micro-organisms and chemicals in bathing water in swimming pools are by direct exposure through ingestion of water or inhalation of aerosols and gases like chloroform during swimming and/or through breaks in the protective skin barrier. Some of the various sources are outlined above.

9.2 Level of Protection

The level of protection is based on cleaning and disinfection routines as well as monitoring of the water quality. The Danish level of protection is considered high, however, the present regulation is under revision to account for the newest knowledge and technical progress.

The new requirements for bound chlorine and trihalomethanes are issued based on both the technical possibilities, but also a consideration for sports people who spend a considerable amount time in the chlorinated water.

9.3 Regulation and strategy

The regulatory requirements for swimming pools are given in the Statutory Order no. 195 of 5 April 1988 issued by the Ministry of Environment and Energy. The new statutory order, already drafted, on swimming pools and their water quality is expected to come into force in 2001. This order will tighten the current requirements outlined in section 9.4.1. This includes a reduction in the maximum allowed levels of free chlorine, bound chlorine and trihalomethanes. The allowed amount of free chlorine is however maintained at a level, which is considered safe in relation to control of Legionella. The

statutory order also includes a demand for automatic chlorine and pH-dosing, a facility which is already available in most public swimming pools today.
A new parameter, the bacteria *Pseudomonas aeruginosa,* has been introduced for hot-water systems, because the bacteria is resistant to disinfectants including chlorine.

DEPA has also investigated whether plasticisers migrating from surface dressings, e.g. PVC foil, or from toys, bathing suits or remains of cosmetics can be found in swimming pool water. Plasticisers are removed by activated charcoal filters, which are available in most indoor swimming pools (75%). DEPA has therefore concluded that there is no need to introduce a demand for regular analysis of plasticisers. For outdoor swimming pools and those indoor swimming pools without charcoal filter, the municipalities should make a concrete evaluation of the need for analyses.

The new statutory order stipulates that chemical substances, identified in spite of the regular monitoring and control and not assigned a quality criteria, e.g. plasticisers, must follow the quality criteria for drinking water. DEPA has also suggested that the Ministry of Building and Housing should establish an approval system for materials used for surface dressings in swimming pools following the same principles, which apply to materials for drinking water systems.

9.4 Instruments

9.4.1 Regulatory instruments

In order to reduce exposure and risk to an acceptable level, a combination of demands for cleaning of visitors, floors, walls, pools etc. and disinfection and other ways of treatment of pool water have been established. This means that the control of water quality comprises a combination of several indicators. Some of these concern micro-organisms, other chemical and physical factors. The microbiological indicator used in Denmark is the germ count. When the germ count is higher than a certain limit value, counts of thermotolerant coliforms and pseudomonas are performed.

Daily monitoring of pool water based on chemical and physical measurements by the responsible for the daily operation and monthly measurements of germ count, plus chemical and physical factors by the official authorities (most often the municipality) are the key elements of Danish regulation on swimming pool bathing water quality in order to enable rapid response and protection of the population.

Daily monitoring of the physical and chemical parameters includes temperature (normally between 24 - 28 °C), pH-value (pH = 7 - 8, preferably between 7.2 - 7.6), free chlorine (0,5 - 3 mg per l) and chlorine in compounds (max. 1.0 mg/l, preferably as low as possible).

Monitoring by the official authorities includes:

- Monthly measurements of germ count, temperature, pH and chlorine.

- If the germ count is higher than limit value (500 per 100 ml), the water is analysed for coli and pseudomonas.

- Measurement of content of organic material four times a year.

- Measurement of disinfectant by-products two times a year.

- Inspection of the pool, the surroundings, and the daily written reports on operation and monitoring.

The requirements are given in the above-mentioned Statutory order no. 195 of 5 April 1988 issued by the Ministry of Environment and Energy.

Restrictions on bathing
Should the hygienic conditions and/or the quality of water in a swimming pool fail to meet the quality criteria, the municipal council shall order conditions improved or - in severe cases - close the pool.

9.5 Actors

The primary actors concerning regulation on swimming pools are listed in table 9.2.

Table 9.2 Actors, roles and responsibilities concerning swimming pools.

Actors	Roles and responsibilities concerning swimming pools
DEPA	DEPA is responsible for the preparation of draft acts and statutory orders, and provides guidance for the work of the regional and local authorities. DEPA is also responsible for sending the results of the bathing water quality to the Commission.
The person who is responsible for daily management of the pools	Daily control of disinfection, cleaning, safety, instruction of visitors, and writing of operation reports.
Municipalities	The Municipal authorities are responsible for the legal administration and are therefore obliged to ensure that the quality objectives of the legislation can be met and maintained. This includes the education of the manager, maintenance of systems and procedures, monthly analyses, etc.
The medical officer of health	The medical officer should be consulted by the municipal council if there is any indication of severe deterioration in the water quality and a suspicion of health effects.

9.6 Evaluation

The health objective of the regulation covering recreational waters is to ensure that swimming pools, spas and similar recreational water facilities are operated safely in order to avoid adverse health effects and illness in people using the facilities. Vulnerable groups, like children, asthmatics, and sports people, who are more frequently exposed, are also considered. The goal is to ensure that the swimming pool water has a quality, which will not impair the health of the population and to keep a disinfection level, which prohibits the existence of pathogenic micro-organisms.

The measures to achieve this objective include cleaning of the body before entering the water, cleaning and disinfection of the pool and water, and regular monitoring and control of chemicals and micro-organisms.

A systematic registration of health related effects from exposure to swimming water and other recreational waters is not available. There are however, known incidents of e.g. legionellosis from inhalation of aerosols in private spas, and Legionella has been identified in public hot-water pools. Acute effects like skin and respiratory irritation resulting from exposure to disinfectants and by-products in the water and in the breathing zone have been described but the resulting impact on human health is not known as it is also the case in relation to possible long-term effects from exposure to these chemicals.

DEPA considers the existing level of protection sufficient to protect human health. However, as it is now technically possible, new and more stringent regulation will be introduced in the near future, which will tighten the requirements regarding water quality and monitoring.

In addition, DEPA is working to introduce an approval system for materials used for surface dressings in pools, following the same principles as for drinking water systems.

In order to further improve safety in relation to recreational waters and the regulatory measures, more knowledge is needed about the by-products from disinfectants used in the pool water and their toxicological properties.

Assessment of possible substitutes to chlorine gas and hypochlorite, which are allowed for disinfection today, is another area of interest. This assessment must also include determination of a monitoring programme and identification of relevant parameters to control as well as a toxicological evaluation of possible by-products.

Any use of alternative disinfectants will also require knowledge about their effect on the pathogenic micro-organisms, which may occur in the water.

9.7 References

Literature

WHO (2000a): "*Guidelines for Safe Recreational-water Environments. Vol 2: Swimming Pools, Spas and Similar Recreational-water Environments. Chapter 3: Microbiological Hazards*" (Final draft for consultation, August 2000).

WHO (2000b): "*Guidelines for Safe Recreational-water Environments. Vol 2: Swimming Pools, Spas and Similar Recreational-water Environments. Chapter 4: Chemical Hazards.* (Final draft for consultation, August 2000).

Legislation

Statuary Order no. 195 of 5 April 1988 on Water Quality in Swimming Pools.
Draft statutory order on Water Quality in Swimming Pools. (December 2000).

10 Chemical substances and products

10.1 Human exposure to chemical factors

Chemicals are everywhere
Chemicals are ubiquitous in a modern industrialised society. Many solutions to technical problems and many new products involve the development and use of new chemicals or known chemicals in new applications.

For Denmark it has been estimated that 20,000 substances, 100,000 chemical products and 200,000 goods/industrial products are on the market (DEPA 1996)[84]. Therefore, sources of exposure to chemicals are a trivial and often unrecognised part of everyday life.

Chemicals, both natural and man-made, may have adverse effects on humans. Some hazardous chemicals may have severe effects such as carcinogenic, reprotoxic or mutagenic effects, other chronic effects or even death. Considerable efforts are therefore directed towards reducing the risk of exposure to these and other chemicals of concern.

Focussing on the areas of concern
The use of chemicals for production of synthetic materials and products, and as components of chemical products for an infinite number of purposes, means that chemicals are everywhere. It is impossible to give a full description of all possible carriers for which exposure of a chemical substance with a potential for human health effects may take place.

The use pattern and composition of a product containing chemicals warrants particular concern where:

- *Use involves hazardous chemicals*
  Chemicals with properties dangerous for human health are an obvious risk factor. Uses that involve pesticides or biocides, organic solvents, acrylates and other substances with pronounced biological effects.

- *Use leads to high exposure*
  Use patterns involving a large turnover of a product, in a particular bioavailable form (gaseous or liquid) or an application leading to a high or long-term human exposure.

- *Use involves vulnerable groups*
  Uses involving vulnerable groups are particular in focus. This may e.g. be a product used by pregnant women, for infants, children, sick or elderly.

---

[84] DEPA (1996) Chemicals – Status and Perspectives. Excerpts from a discussion paper from Danish EPA, English Summary and List of Undesirable Substances.

A number of products have usage and application patterns that place them in a 'high' exposure group. These are addressed in the following.

Delimitations
This chapter reports on the environmental factors as they exist in the form of chemicals, their sources, uses and regulations. It also describes the most prominent instruments, actors and strategies of the issue in Denmark.

Focus is directed towards the chemicals and their use pattern, where they are regulated by DEPA. This is particularly the marketed chemical substances and preparations as such, and where these chemicals come in direct contact with non-professional human users, e.g. household chemicals and consumer articles and goods.

Some areas where a considerable direct exposure to chemicals may take place are not regulated by DEPA. This includes the working environment, food and pharmaceuticals. Also, indirect effects associated with the individual's consumption of tobacco, alcohol, drugs, general lifestyle or living conditions are excluded. A more detailed description of responsibilities of Danish authorities in regulation of health and environmental factors is given in chapter 2 and 3.

10.1.1 Chemical factors

This chapter deals with products, where the chemical substances were put in the original product intentionally or where they appear as contaminants from used raw materials. Therefore, the term 'environmental factor' is adjusted to 'chemical factor' since the exposure will be directly from the original source with no implication of environmental issues. The exposure from the environment is treated in each of the media chapters.

Distinction is made between chemical substances and preparations in the Danish Law on Chemical Substances and Products:

- Chemical substances are the natural elements and their inorganic or organic compounds as they are naturally or industrially produced.

- Chemical preparations which are mixtures of several substances (such as paints, detergents, cosmetics, etc.) are sometimes referred to as chemical products.

- In addition to chemical preparations as defined in the statutory order, numerous consumer products in the form of articles and goods (a few examples are toys, textiles, building and construction materials) may also lead to exposure covered by the regulation. Typical consumer products will be addressed separately in this chapter.

It is estimated that in the EU about 30,000 - 50,000 chemical substances are marketed, and approx. 2,700 are so-called 'High Production Volume Chemicals' (> 1,000 tons marketed per year) for which a certain amount of data on inherent properties must be available. Data for these substances and also the approximately 20,000 'Middle production Volume Substances' (>10 tons, <1000 tons) are made available in the CD ROM database 'International Uniform Chemical Information Database' (IUCLID) developed by the European Chemicals Bureau (ECB 2000, IUCLID, Version 2).

Other substances are marketed in lesser amounts, some in very small quantities. Among these, there are substances of no obvious concern (e.g. common salts, carbohydrates) where the need for information is less crucial but also substances for which a targeted effort is required. For a vast number of the 100,000 chemicals little or close to nothing is known regarding their health and environmental properties.

Chemical properties/ harmful effects

The number of potential contact points between chemicals and humans are enormous. In order to identify the risk of chemical exposure, new and existing chemical substances must be classified with respect to human and environmental hazard based on available information on their inherent properties.

Only a limited number of the substances on the market (approx. 5,000) have been officially classified by the authorities and included in the list of dangerous substances (DEPA, 2000). However, producers and importers are obliged to evaluate the chemicals they produce and import. Furthermore to provisionally classify and label the chemicals they should meet the requirements of the statutory order on classification, packaging, labelling, sale and storage of chemical substances and products.

Table 10.1
Examples of the chemical factors receiving most attention regarding possible human health effects in the regulation of chemical substances, chemical preparation and consumer articles and goods (DEPA 1996)[85].

Chemical factor	Origin and characteristics	Health Impact
Metals (e.g. lead, chromium, cadmium and mercury)	Metals are used for a variety of purposes including colouring, stabilisation and as components in batteries. Metals also occur naturally in many products from which they may potentially be released.	Selected impacts are e.g. Lead and mercury are accumulated in the body. Bothorganic and inorganic forms are toxic. Cadmium is cumulative and has a chronic adverse effect on renal function. Chromium (in oxidation state 6) has carcinogenic and possibly reproductive effects.
Nickel	Widely used in alloys and jewellery.	Nickel is a common allergen.
Pesticides	Used in agriculture and forestry, but also in pest control for domestic purposes. High exposures may occur in non-professional use.	Many different effects from the range of substances.
Phthalates	Plasticisers in PVC and tensides occurring in detergents and cosmetics.	Reproductive effects Endocrine disruption
VOCs	Paints and varnishes, glues, degreasers and generally as solvents.	Acute toxicity Neurotoxicity Allergens
Fragrances	Personal hygiene and other odourised products.	Allergens
Polyaromatic hydrocarbons (PAH)	Spillages and deposition of tar products (tar and asphalt production, gasworks, impregnation of ropes and fishing net, wood preservation, tar paper production, etc.)	Benz(a)pyrene and several other PAHs have been found to be potent carcinogens in animal studies. There are also evidence for carcinogenicity in humans associated with exposure to these substances

[85] DEPA (1996) Chemicals - Status and Perspectives. Excerpts from a discussion paper from DEPA, English Summary and List of Undesirable Substances.

10.1.2 Sources and exposure

Chemical substances
The chemical substances, preparations, articles and goods sold to professionals and laymen, are the source of numerous direct exposures of humans to chemical factors. A great number of different items are in retail and a considerable effort is directed into labelling the chemical substances with risk and safety phrases. The objective is to limit the anticipated exposures by restricting the use or prescribing the use of specific protective equipment.
Single substances like certain solvents, metals, oils, acids and bases (Example 1) are also marketed, sometimes giving rise to high exposures to the individual substance and subsequently their related adverse effects.

EXAMPLE 1 SOURCES OF CHEMICALS

Chemical substances	Articles and goods
• Solvents	• Toys
• Metals	• Clothes
• Oils	• Building materials
Chemical preparations	
• Detergents	
• Paints & varnishes	
• Cosmetics	
• Pesticides	

Chemical substances released or migrating from articles and goods is another source of exposure, which often requires detailed analysis in order to identify and quantify the actual exposure. This is especially the case when the chemical substances are a result of contamination of the raw material and not intentionally added to the products. Recent examples of such exposures are the findings of traces of tributyl tin in babies' napkins and asbestos in crayons.

Chemical preparations
The number of different chemical products (mixtures of substances e.g. paints, varnishes and detergents) are greater than the number of substances and may individually release health affecting environmental factors during their storage, use and disposal. A strategy for limiting exposure following the same path as for the chemical substances is followed.

Some specific substances have been identified as particularly hazardous: lead, cyanoacrylates, isocyanates, epoxy compounds, active chlorine and cadmium. Additional labelling is required for certain preparations containing these substances.

Substances in consumer articles and goods
Many consumer products are not perceived as the possible source of chemical factors, but the chemicals are used in the production of consumer goods. They serve a purpose, as part of the structural material, the decoration or similar, or reside as a residual concentration or contamination of the produced goods. Examples, such as lead and cadmium in glazing and enamelware, plasticicers in cling film or flame retardants in electronic equipment, may be mentioned.

Indoor living conditions may be greatly affected by the choice of building materials because of the long-term exposure and the huge areas/amount of material. Volatile compounds receive special attention, since evaporation from walls and floors may lead to significant concentration in confined, not ventilated areas with large surfaces. One example is the assigned limit value for evaporation of formaldehyde from chipboards, another issue under much consideration presently is the emission of plasticizers from PVC flooring materials.

Evaporation of chemicals from construction materials is recognised as a major component in determining indoor climate. These materials include e.g. glues, fillers, foams and other polymer materials such as paints, lacquer and varnishes. Most of the exposure is by inhalation and the effects are related to volatile organic compounds used as solvents.

Other chemicals migrating from building and construction materials during use are increasingly in focus as sources of potential health effects. The use of acrylates and related monomers may lead to direct dermal exposure, but the release and subsequent indirect exposure from the environment of e.g. plasticisers migrating from PVC has recently also been addressed.

Cleaning products
Household cleaning products may contain hazardous chemicals such as corrosives, irritants and substances toxic to humans or the environment. The products may fall in many categories. The diversity is exemplified by a few products from the cleaning sector: Dishwashing, car wash, drain cleaner, wax, dry cleaning agents, engine wash, window cleaning, protective coatings, stain remover, speciality metal cleaning products, and decalcifiers.

The chemicals used in cleaning products are mainly organic and a number of them are among the undesired substances: alkylphenolethoxylates, phthalates and many are solvents.

Cleaning products are used in large quantities and for some of these products high exposures can also be foreseen, especially substantial dermal exposure. Many cleaning products containing detergents are used in connection with warm water, which increases the risk of skin absorption and inhalation of aerosols and gasses. For a vulnerable group such as children a higher than average exposure must be anticipated from residues on floors and other surfaces, and from inhalation and contact to dust particles.

Cosmetics
Cosmetics are typically used directly on human skin and consequently a large dermal exposure is expected. Some are used near mucous membranes (e.g. eyes and mouth) which may increase absorption of the substances or repetitively on large skin surfaces e.g. lotion for babys/infants. Examples include lipstick, perfume, shampoo, make up, deodorants, sun tan lotion, and toothpaste.

Adverse effects have been attributed to some of the substances traditionally used in cosmetics in low concentration. In high concentrations, these substances show mutagenic, allergenic and reproductive toxicity, e.g. isopropyl alcohol, musk xylenes, DEHP.

Allergy is the most common adverse effect related to cosmetics often caused by preservatives and fragrances. A reason for concern is supported by the fact that the incidence of cosmetic allergy is increasing.

Toys
Infants and small children (< 3 years) represent a vulnerable group by themselves, but also requires special attention because they have high hand-to-mouth ratios and risk exposure via mucous membranes. Much effort is therefore directed towards evaluating migration of substances from the products under conditions mimicking the gastro-intestinal milieu and the substance's oral toxicity.

The phthalates have been one of the target substances for restrictions recently, since the migration and risk of effects from these substances in flexible PVC were deemed unacceptable by the Danish authorities.

For a number of metals used for colouring in grease paint, paints and crayons limit values have been applied since it is estimated that both oral and dermal exposures can be expected.

Clothes/textiles
In clothes and other textiles a similar attention is given to migration of material components, production chemicals and residues of pesticides or preservatives. The main cause for attention is not the hazard associated with the substances themselves, but rather the fact that a close contact may take place between the material and a large part of skin surface for a relatively long time.

Pesticides
Exposure to pesticides (including biocides) is of particular interest because of the proven biological effects and the products therefore represent a high-risk area in terms of toxicity. Human exposure may take place during mixing of formulations and filling of equipment, and in the application process in the field. Especially the non-professional user may wear insufficient protective equipment or none at all and is therefore not protected against dermal exposure and inhalation (www.agrsci.dk)[86].

A higher than average risk level may also be attributed to children playing on pesticide treated lawns. Likewise, the treatment of kindergartens, playing rooms and buildings to combat e.g. insects and other pests may infer higher risk to children.

Biocides occur in many chemical products for preservation purposes, but biocides are also used in building and construction materials, fabrics and other materials to prevent the biological degradation processes.

10.1.3 Risk to human health

Relatively little is known about the actual health effects and the effects of the combined impact from different sources on public health related to the use of chemicals. In some areas, a certain level of knowledge is available. The acute effects of a number of chemicals are relatively well known from workplace and consumer exposure situations, accidents, and poisoning incidents, e.g. from reporting of acute toxicity to emergency sections at hospitals and to the poison control centre. Chemical pneumonia from drinking and aspiration of lamp oil is one such example. In relation to acute effects like toxic, harmful, irritant and corrosive effects, it is usually easy to establish a relation between

---

[86] DEPA (2000) "More about Chemicals", DEPA homepage.

the exposure to a given chemical and the actual effect, because the response follows immediately after the exposure.

A profound knowledge of the combined pressure of chemicals to the health status in Denmark is not available, and obviously neither of chemicals as they occur in consumer products.

In general, it is difficult to establish firm scientific evidence for long-term effects like cancer, mutagenicity and reproductive toxicity in humans because of numerous confounding factors related to life-style which can be difficult to account for in epidemiological studies. Long-term effects develop over a long period (sometimes many years) and the exposure pattern becomes very complex in epidimiological studies making a causal relationship between exposure and effects very difficult to establish. There are however, some chemicals for which adequate data for this relationship has been generated both in animal experiments and from observations in humans, e.g. carcino-genic substances such as benzene, asbestos, chromium(VI)-compounds, ethyleneoxide, nickel compounds and vinyl chloride.

Pesticides are well investigated compared to other chemicals. Both acute and chronic effects are tested in animals and the results are extrapolated to humans. DEPA does not find it ethical to use tests on humans with regard to pesticide exposure.

In 1995, it was concluded by the Ministry of Environment and Energy that some chemical factors may influence the life expectancy in a negative direction, and perhaps does so in Denmark. A number of specific factors and effects are mentioned: Chemical carcinogens as such, radon in indoor air, ozone deple-ting substances increasing UV transmittance, lead and dioxins increasing neural dysfunction, and compounds with reproductive effects. A range of allergenic responses, including eczema and asthma, can also be coupled to exposure to chemical substances and products.

When it comes to long term exposure of the population, knowledge is more scarce, as it can be very difficult to relate the use of various chemicals to the incidence of cancer, reproductive toxicity, allergy and other effects. Again knowledge from workplace exposure and related effects provides some indication of a relation between e.g. the development of eczema, allergies and reduced tolerance to chemical substances, and the exposure of the population to chemicals.

Knowledge about the cancer incidences in the population is difficult to relate to the use of chemicals. This is because very little is known about the actual level of exposure to chemicals and also because a number of life style factors may influence the development of cancer. The impact on the state of health of combined exposure to chemicals and chemicals in combination to other environmental factors like e.g. noise is another area characterised by limited knowledge.

Lack of knowledge makes it therefore very important to identify exceptional exposure situations involving hazardous chemicals, high and repeated exposure and exposure of vulnerable groups like children and pregnant women. Realising this, DEPA has intensified its efforts to identify such specific exposure situation, which will also form a background for the future protection of vulnerable groups.

This section focuses on the direct exposure to 'containerised' substances and products in the human sphere. The main concerns for risk of health threatening exposure are the previously mentioned areas with

- Hazardous chemicals
- High exposure
- Vulnerable groups

The exposure to chemical factors related to chemical substances and preparations, articles and goods is by far the most direct exposure situation. In this area, however, indirect exposure takes place as well, e.g. in the form of pesticide residues in food or substances migrated from food packaging material.

The main overall distinction in exposure pattern is between the chemical substances, preparations and products used in the industry, incl. agriculture, and those used in the household sector. Typically, more hazardous chemicals are allowed to be used in the industrial sector because the users in the working environment have access to training and protective equipment. Especially, more CMR substances and products may be used (CMR is short for carcinogenic, mutagenic and reproductive harmful substances). However, occupational exposure of professionals is not covered here.

In a number of instances laymen also risk exposure to 'professional' products. These include the many uses by 'do-it-your-self' people using such products in building and construction, painting and decoration, washing, cleaning and rinsing of surfaces and items. It is therefore the products (the vehicles) rather than the sectors, which are in focus as the source of exposure for the non-professional user of such products. As for the consumer, a great number of items comprise the everyday sources of exposure and they are also coupled to the products – not the sectors. The exposure is therefore addressed *via* the products of use.

Children, as well as the unborn child, have in some cases appeared to be uniquely vulnerable to chemical substances because of their biological growth and development. Furthermore, children may be more heavily exposed than adults to certain chemicals and pollutants in the environment because children, on a body weight basis, breathe more air, drink more water, and eat more food than adults. Additionally, their behavioural patterns, such as play close to the ground and hand-to-mouth activities, can increase their relative exposure.

10.2 Level of protection

From the beginning, the primary objective of chemical regulation has been to protect humans from the adverse health effects from exposure to chemicals, also illustrated by the previous Danish Poison Act from 1961.

The Poison Act applied to substances, which were not covered by other acts, e.g. the Pesticide Act. According to the poison act, substances were classified and categorised in one of the following categories: 'strong poison', 'poison', 'harmful', 'harmful organic solvent', and 'harmful gas'. Substances were not evaluated with regard to long-term effects. Criteria for long-term effects were introduced through an amendment to the *European Substance Directive* which was first issued in 1967 (EU, 1967). Much later, through the 12th adaptation to this directive, criteria for evaluation of environmental effects for substances were introduced.

The main tools used to define and administer the level of protection are risk assessment procedures and classification criteria for classification of chemical substances and preparations. In general, the classification of chemical substances forms the background for all downstream regulation.

For some specific chemical products, e.g. plant protection products and biocides, the level of protection is primarily built into pre-marketing approval schemes, as these products because of the way they are used may be particularly hazardous to the health. In the process of the approval by the authorities, a detailed risk assessment is performed and the need for specific restrictions attached to the use of the products is evaluated before these are put on the market. In the downstream regulation restrictions in marketing and use are either based on the classification of substances and preparations or on specific risk reduction measures. The latter results from risk assessment of the particular substances as part of the risk assessment procure for new and existing substances. For example substances classified as *Very toxic* or *Toxic* because of CMR effects cannot be sold to the general public. These measures also contribute to sustain a certain level of protection.

Vulnerable groups like children and pregnant women are often more at risk to exposure from chemical factors than the general public and are therefore also getting increasing attention in relation to regulatory development and the level of protection as such. As a result of this, DEPA is working to increase the level of protection in relation to certain uses of chemicals, e.g. with regard to toys and cosmetics. Another area of concern is exposure to endocrine disruptors, which are currently not addressed directly in the regulations. DEPA therefore finds it very important to improve this area in the regulations.

It is difficult in quantitative terms to define the level of protection in chemical regulation, as protection levels from different kinds of regulations in different areas can hardly be compared. Thus a protection level in more qualitative terms may be reflected in an overall view of which kind of regulations that have been issued.

Denmark has, in order to obtain a high level of protection of human health, prioritised bans and restriction of a number of problematic substances including heavy metals like cadmium, mercury and lead, ozone depleting substances, creosote, brominated flame retardants, phthalates and PVC. These restrictions are motivated by either the hazardous properties, the amount used, the method of use or the exposure of vulnerable groups.

The principles for setting health based quality criteria for specific chemicals in order to prevent health hazards in the human population caused by chemical substances as pollutants are discussed in relation to the various media (air, soil and drinking water) and are outlined in more detail in Appendix 1.

10.2.1 Pre-marketing approval

Plant protection products and a great variety of biocides are subject to pre-marketing approval schemes, which in a very direct manner contributes to the level of protection. In general these chemicals are considered to be particularly hazardous to health and are used in large quantities.

Pre-marketing approval implies that the responsible importer or manufacturer must submit a detailed dossier to the competent authority, DEPA. DEPA will then make an evaluation of the data in the dossier before an approval can be assigned. DEPA can also decide to restrict the approval if the forwarded dossier gives reasons for concern in relation to e.g. the planned use.

10.2.2 Classification and labelling of substances and preparations

The purpose of the classification and labelling system is to consider the hazards arising from normal handling and use of substances and preparations in the form they are placed on the market, i.e. to:

- identify all the inherent physico-chemical and toxicological properties and for substances also the environmental properties, which may involve a risk during normal handling and use, - and

- inform the general public about the hazards and adequate precautionary measures for handling and disposal in order to prevent accidents and harmful effects among the users.

Substances are categorised according to the identified properties in one or more categories of danger expressing physico-chemical, toxicological and environmental properties. Only classification with respect to human health is addressed in this section, i.e. classification based on toxicological properties. The following danger categories are related to health:

- Very toxic
- Toxic
- Harmful
- Corrosive
- Irritant
- Sensitising
- Carcinogenic
- Mutagenic
- Toxic to reproduction

The classification into these nine danger categories is based on existing data and reflects the present level of knowledge and possibilities for testing the various endpoints. These criteria are continuously developed as more knowledge is generated. DEPA has especially worked to promote more adequate criteria for neurotoxicity, immunotoxicity, reproductive toxicity and impact on the endocrine system. This is also to be better prepared for handling the endocrine disrupters in relation to the endpoints for this newly acknowledged effect.

For endocrine disruption[87], appropriate test methods have still not been developed for the various endpoints, and this effect is therefore not considered by

[87] The endocrine system consists of a set of glands and the hormones they produce. Endocrine disrupters are defined as follows according to an international agreement (COM, 1999): a) A potential endocrine disrupter is an exogenous substance or mixture that possesses properties that might be expected to lead to endocrine disruption in an intact organism, or its progeny, or (sub)populations. b) An endocrine disrupter is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub)populations.

the classification system. Also for some of the well-known effects like neurotoxicity and respiratory allergy, the test methods have been questioned and are still not fully developed.

Because of the problems with testing for chronic brain damage, it has been difficult to reach agreements in EU about how to evaluate and classify many organic solvents with regard to neurotoxicity in the past. Many organic solvents were only classified with regard to flammability in EU, and Denmark has used the safeguard clause in several situations in order to introduce a classification reflecting the neurotoxic potential as expressed through the risk phrase R48/20 (*Danger of serious damage to health by prolonged exposure through inhalation*). Recently, two additional risk phrases have been introduced to cover typical solvent-related health hazards, namely R66 *(Repeated exposure may cause skin dryness or cracking)* and R67 *(Vapours may cause drowsiness and dizziness).*

The criteria for classification do not focus on sensitive subgroups, e.g. children. However, a number of R- and S-phrases are specifically related to the protection of children and/or pregnant women.

As classification is based on the inherent properties of the substance or preparation in the form it is marketed, it does not take the actual use situation and the exposure into consideration. For example whether the chemicals are intended to be heated during use, diluted, sprayed or processed in any other way.

The classification of a substance / preparation comprises the relevant danger categories and the related risk phrases. Risk phrases express the type and degree of danger from the different routes of exposure. In the classification system there are in addition some risk phrases, which can be assigned to substances classified for other effects. These phrases cover accumulation in the human body and danger to breast-feeding children. The classification system includes currently 65 individual risk phrases of which 33 are directly related to health hazards.

Examples of danger categories and related risk phrases:

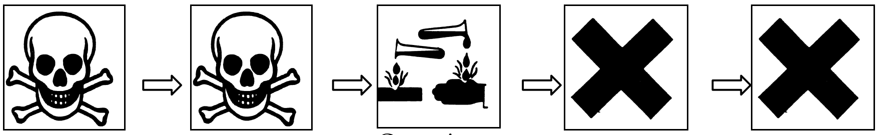
Danger category	**Risk phrase**
Toxic	R23: Toxic by inhalation
Sensitising	R43: May cause sensitisation by skin contact
Corrosive	R35: Causes severe burns
Mutagenic (Mut 3)	R40: Possible risk of irreversible effects
Carcinogenic (Carc 1 or 2)	R49: May cause cancer by inhalation

Labelling serves the purpose of communicating the potential hazard through danger symbols, risk and safety phrases and other required information on the label.

The use situation is considered by labelling the substances and preparations with safety phrases expressing adequate precautionary measures in relation to handling and disposal of the chemicals. Safety phrases, some of which are obligatory, are assigned based on the classification of the substance/preparation and a defined set of criteria. Preparations which are intended to be applied by spraying must be assigned with specific safety phrases warning about the exposure (S23[88]) and giving advise on protective measures (S38[89] or S51[90]), as the application is expected to give rise to a considerable exposure.

The health related danger symbols and indications of danger are shown in Figure 3 in order of their degree of danger.

Figure 10.1 Health related danger symbols



Very toxic | Toxic | Corrosive | Harmful | Irritant

The labelling rules also includes some requirements for child-resistant fastenings and tactile danger warnings for certain hazardous chemicals aiming to protect vulnerable groups like children and blind people against exposure from the chemicals.

The classification and labelling rules and the ranking of the chemicals in different classes according to their degree of danger form the basis of a large number of administrative rules with regard to restrictions in marketing and use and further priority setting in much of the downstream regulation. Only a small proportion of the substances already on the market are classified in the regulations, a fact which may be a concern in relation to the level of protection. In order to compensate for this problem, DEPA supports the use of group classification of chemical substances and QSAR as methods to evaluate the substances in order to raise the level of protection. DEPA has therefore recently issued a draft guidance list for self-classification of dangerous substances. The list contains 20,624 substances, which have been classified with regard to acute toxicity from ingestion, allergy from skin contact, mutagenicity, carcinogenicity or dangers to the aquatic environment. The substances have been identified among 47,000 substances using QSAR (Quantitative Structure-Activity Relationship) computer modelling. A final list is expected to be issued in 2001.

10.2.3 Risk assessment of chemical substances

Risk assessment of chemical substances forms the basis of the risk reduction strategies and thereby the level of protection. Lack of data is, however, one of the challenges when securing a sufficient level of protection of human health from exposure to chemicals. Only a limited number of the chemicals which are already on the market have been adequately investigated and even fewer have been through the risk assessment procedure.

The risk assessment process, in relation to both human health and the environment, entails a sequence of actions: effect assessment (hazard identification and dose (concentration) - response (effects) assessment), exposure assessment (estimation of the concentrations/doses to which human populations or environmental compartments are or may be exposed), and risk characterisation (estimation of the incidence and severity of the adverse effects

[88] S23: Do not breathe vapours / spray.
[89] S38: In case of insufficient ventilation wear suitable respiratory equipment.
[90] S51: Use only in well-ventilated areas.

likely to occur in a human population or environmental compartment due to actual or predicted exposure to a substance).

The risk characterisation is then carried out separately for three subgroups of the population: workers, consumers, and man exposed indirectly via the environment. In the risk characterisation for consumers and man exposed indirectly via the environment, the interspecies variation is taken into account when considering the margin of safety (the ratio between the *No Observed Adverse Effect Level* (NOAEL) or *Lowest Observed Adverse Effect Level* (LOAEL) and the estimated exposure).

The principle of general risk assessment of chemicals is to evaluate the inherent properties (the hazards) of the chemical and to make a risk assessment taking account the most probable exposure of man and environment, with special reference to protect workers, consumers and other persons ex-posed via drinking water, food, soil or other parts of the environment. Most often exposure data are not available for all of these groups and therefore standard scenarios reflecting realistic worst case situations are used and also modelled in computer models. In this respect, the Danish and other product data from product registers like the Danish can be an important source of information about the actual use of many chemicals in the workplaces, but in general the exposure assessments are subject to some uncertainty. For some substances (e.g. phthalates), children have been considered as a specific subgroup of consumers as they may be exposed to these substances in a way which is not considered relevant for adults. Furthermore they may be more susceptible to the exposure of specific chemicals e.g. endocrine disrupters.

The EU risk assessment procedure for existing substances listed on EINECS[91], applies in principle to more than 100,000 substances, but in practice the 141 priority substances has been selected among the 2,700 substances produced in the highest volumes (above 1000 tons). Only very few substances have been processed through the risk assessment procedure until now. It is not the idea to assess all the substances on EINECS, partly because it is impossible to manage, but also because a considerable number of the substances most likely are not on the market today. Other methods to be used for the assessments have been discussed, e.g. the previously mentioned substance groups evaluations and use of Quantitative Structure-Activity Relationships (QSAR).

10.2.4 Restrictions in use

Rules concerning restrictions in use or actual bans of substances hazardous to health or environment can either be based on decisions taken in international fora or they can be based solely on national decisions.

Denmark has given priority to bans and restrictions of a number of substances including heavy metals like cadmium, mercury and lead, ozone depleting substances, creosote, brominated flame retardants, phthalates and PVC. These restrictions are motivated by either the hazardous properties, the amount used, the method of use or the exposure of vulnerable groups.

[91] EINECS: (European Inventory of Existing Commercial Chemical Substances). EINECS is a static list prepared and published by the Commission and includes 100,116 substances regi s-tered on the market in the European Community between 1 January 1971 and 18 September 1981.

10.2.5 Precautionary principle

The precautionary principle is a principle that opens up for regulatory action on the basis of suspicions for harmful consequences rather than waiting for cases or a full scientific evidence. In the context of this report, the use of the precautionary principle may be relevant for the aim of protecting vulnerable groups in the population against potential hazardous exposures for which the harmful consequences are not fully understood.

The precautionary principle has been incorporated in a series of international treaties (e.g., the EU Amsterdam Treaty from 1998) and declarations. In many of these, the principle has been connected mainly to hazardous chemical substances, but there are also examples of broader approaches to environmental issues.

In Danish legislation the precautionary principle is not explicitly mentioned, but it is often reflected in the introductory comments to various environmental acts, the central ones being the Environmental Protection Act, the Chemical Substance and Product Act, the Marine Environment Act, and the Gene Technology Act.

Both in Denmark and abroad, there has been increasing focus on the precautionary principle in recent years. In line with the increasing complexity of environmental issues, politicians, enterprises, and authorities are expected to allow this doubt to benefit the health or the environment.

However, a uniform and internationally agreed interpretation of the precautionary principle does not exist. Denmark has argued that the principle should be undertaken where potentially adverse effects are of concern, but scientific evidence is unavailable due to lack of data. Finally, the precau-tionary principle is mentioned in the final conclusions from the Nice summit. Here the Council states that under international law, the Community and the Member States are entitled to establish the level of protection they consider appropriate in risk management. Further, that they may take the appropriate measures under the precautionary principle and that it is not always possible to determine in advance the level of protection appropriate to all situations.

10.2.6 Protection of vulnerable groups

In 1998, the Ministry of Environment and Energy participated in a conference on children and chemicals together with several other ministries. Each ministry presented a status report on how the protection of children and pregnant women is incorporated in its work. The overall impression from the discussions was that children and pregnant women should generally be recognised as special risk groups with respect to effects from exposure to chemical substances. As a consequence, a project was initiated by DEPA titled "Children and the unborn child: exposure and susceptibility to chemical substances – an evaluation". The aim of the project was to elaborate a detailed review and update the knowledge on the exposure and vulnerability of humans to chemical substances during the embryonic, foetal and postnatal periods. The report is intended to form the scientific basis for future regulatory work of the DEPA in the protection of children and the unborn child to environmental chemical substances and it also gives some recommendations for this work.

The regulation of chemical substances is generally based on the present knowledge regarding adverse health effects and risks related to the use of the substances. However, the available data on a specific chemical substance is seldom sufficient to evaluate whether children or the unborn child should be considered more vulnerable than adults. Concerning specific end-points such as fertility and teratogenicity, data exist only for 20 to 30% of the 2,700 high production volume chemicals, and for thousands of chemicals produced in smaller quantities, this percentage is expected to be considerably lower. Furthermore, for most chemical substances, limited data are available concerning exposure of children as well as of adults.

From a regulatory point of view, different approaches can be applied in order to protect children, including the unborn child, from adverse health effects resulting from exposure to environmental chemical substances. One regulatory approach is to improve the risk assessment of chemical substances by including a requirement for data specifically relevant for the protection of children, including the unborn child. Another approach is to pay more attention to children and pregnant women in the risk management process.

10.3 Regulation and strategy

10.3.1 The Danish strategy

Regulation of chemicals is under the auspices of the Ministry of Environment and Energy. In the 1980s and 1990s, Denmark strengthened efforts in the field of chemicals. In 1999, the Danish government presented a new strategy on chemicals, for the period up to 2002, aiming at strengthening international co-operation, making the chemical industry more responsible, strengthening national regulation and enforcement and increasing public access to information (DEPA, 2000).

DEPA has issued stategies and actions plans in e.g. the following areas:

- Brominated flame retardants
- Phthalates in flexible PVC
- Ozone depleting substances
- Pesticides
- Heavy metals

Information about the action plans are available at DEPA's homepage: http://www.mst.dk/activi/01000000.htm.

10.3.2 Objectives and principles

Objectives
The primary objective of the chemicals regulation is to prevent health hazards and environmental damage caused by the use of chemicals and to promote the use of cleaner technology through the administration of *the Act on Chemical Substances and Products.*

In DEPA's strategy for intensified efforts in the field of chemicals, the main objectives are presented as follows:

- the consumption of problematic chemicals shall be reduced

- the control shall be strengthened, manufacturers responsibility increased and the consumers access to information improved
- the EU risk assessment procedure shall be made more coherent, simplified, efficient and faster
- the Danish efforts to secure a chemicals regulation at a global level should be strengthened.

Principles
Chemical regulation in Denmark rests in general on the following principles and instruments:

- Notification and approval of chemical substances and preparations
- Evaluation, classification and risk assessment of chemicals
- Bans or restrictions
- Substitution of dangerous chemicals with less dangerous ones
- Use of cleaner technology and products
- Inspection and penalties
- Information and campaigns
- Voluntary agreements
- Green guidelines for purchasing
- Taxes and fees
- Subsidies

10.3.3 Legislation on chemical substances and products

Danish regulation in the chemical area is, as mentioned, strongly related to the European Union legislation, which in this area is mainly based on totally harmonised directives. Classification and labelling, notification of new chemicals, use restrictions, and hazard and risk assessment are all areas where full harmonisation applies. In some of the directives the so-called 'safeguard clause' exists which makes it possible for the Member States to implement provisional rules, which are stricter than the rules of the EU. Denmark has on some occasions used this clause, e.g. in relation to classification of certain organic solvents.

Denmark has also issued more strict regulations in areas, covered by minimum regulation in the EU. This regards for instance ozone depleting substances.

In addition to the regulation based on EU directives, Denmark has maintained and issued specific national regulation in areas not addressed by EU regulation, e.g. in relation to mercury, lead and restrictions of substances which are allowed in aerosol containers. Another example is the permit system whereby a consumer must obtain permission from the police to buy toxic substances.

10.3.4 Legislative background

Existing Community legislation on environmental and human health aspects of chemicals is based on a three-stage approach. It includes a hazard identification stage, in which a substance's inherent capacity to cause adverse effects on human health and the environment is identified, on the basis of the intrinsic properties of a substance. The second stage consists of risk assessment, which is based on an assessment of the hazard combined with an assessment of exposure to the chemical substance. The third and final stage is one of risk management, in which strategies for the management of the risks are developed. This approach is reflected in the EU regulation.

The main EU Directives on chemicals governing Danish regulations are shown in Appendix 6.

National legislation and implementation

The Act on Chemical Substances and Products
The main act regulating chemicals is the Act on Chemical Substances and Products. This act was issued in 1979 and has been amended and revised several times, latest in 2000. The act covers all chemical substances and products and is intended to prevent health hazards and environmental damage caused by the use of chemical substances. It also aims at promoting the use of cleaner technology through the administration of the Act. The Act shall ensure that the dangers presented by substances sold in this country are highlighted, and that sale and use of chemical substances and products known or believed to be hazardous to health are regulated.

As a general rule, the Act does not regulate the content of chemicals in common products and goods, however in certain sections of the act, goods are included. Exposure of humans to chemicals diffusely leaching from consumer goods is only covered by specific regulations. Described in a simplified way, one could say that the environmental regulation in particular regulates environmental conditions involved with production, while the chemical regulation contributes with rules aimed at the later stages in the life cycle of the chemicals, e.g. distribution, use and as waste. (DEPA, 1996).

Text box 10.1 Objectives and Scope of the Act on Chemical Substances and Products

1.(1) The objective of this Act is to prevent hazards to health and damages to the environment in connection with manufacture, storage, use and disposal of chemical substances and products.

2) In connection with the administration of the Act, the possibilities of promoting cleaner technology and of limiting problems of waste disposal can be stressed.

2.(1) The Act aims at ensuring that the necessary information is provided on chemical substances and products sold in Denmark, and that the sale and use of chemical substances and products which present, and on the basis of available investigations or experience are suspected to present, hazards to health or the environment, can be regulated.

A number of statutory orders have been issued pursuant to ACSP, banning or restricting the use of a number of substances, e.g. heavy metals and ozone depleting substances.

Classification and labelling

Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (the Substances Directive), is an important single market directive that seeks to ensure the operation of the European single market in chemicals and to provide high standards of human health and environmental protection.

In Denmark, the Statutory Order on classification, packaging, labelling, sale and storage of chemical substances and preparations (no. 734 of 31 July 2000) implements the relevant EU Directives into national legislation. The Statutory Order provides the regulations for evaluating the inherent properties of a chemical substance or preparation in relation to hazard identification and assessment in line with the requirements in the *Substance Directive* described in 10.2 and Appendix 5.

Denmark has issued a statutory order on the *List of dangerous substances* which implements Annex I to the *Substance Directive*. For white spirit (CAS-no. 8052-41-3) and solvent naphtha (CAS-no. 64742-88-7) Denmark has used the safeguard clause and implemented a more strict national classification including the risk-phrase R48/20 (*Danger of serious damage to health by prolonged exposure by inhalation*). The latest revision of the list (no. 733 of 31 July 2000) implements the 26th adaptation to the *Substance Directive*. Another national feature is the "*Ae*" code assigned to certain substances in the list. Substances with this code must not be used in spray canisters (aerosol containers) unless other legislation lays down special provisions hereon. The Statutory Order no. 1042 of 17 December 1997, on restriction of the sale and use of certain dangerous chemical substances and products for specific purposes includes a provision that spray canisters must not contain substances classified as "very toxic" or "toxic" and these substances are therefore also assigned the "*Ae*" code in the list.

As described in section 10.2.2, DEPA has recently issued a draft guidance list for self-classification of dangerous substances comprising 20,624 substances, which have been identified using QSAR. The accuracy of the predicted classifications varies from approximately 70 to 85%. The list is not intended to be mandatory, but exclusively to be a guidance list in case no other documentation is available.

Notification of new substances

A new chemical substance is a substance, which is not listed in EINECS as being on the European market in the period 1 January 1971 and 18 September 1981. Substances notified in the period from 18 September 1981 are listed on ELINCS (European List of Notified Chemical Substances), a list of approximately 400 substances.

New chemical substances must be notified with DEPA. Any manufacturer or importer of a new chemical substance shall, prior to sale, submit notification of the substance to the Danish Environmental Protection Agency. The detailed notification file must include, inter alia, a description of the intrinsic physio-chemical, toxicological, and eco-toxicological properties of the substance. The larger the amount of substance placed on the market, the more data must be submitted to the authorities. The notifier may also provide a preliminary risk assessment to support the succeeding risk assessment procedure carried out by DEPA.

The following chemical substances exclusively imported or sold in the following products ready for use are excluded from the notification requirement:

1. Medicinal products for human or veterinary uses.
2. Foodstuffs.
3. Animal feeding stuff.

4. Radioactive substances as defined by Directive 80/836/EEC.[92]
5. Mixtures of substances in the form of waste.
6. Pesticides to be authorized under Part 7 of the Act.
7. Cosmetic products.

Between September 1981 and September 2000 less than 10 substances have been notified in Denmark, where only limited production of basic chemicals takes place.

Restrictions in marketing and use

The ongoing amendments regarding the main EC *Restrictions Directive* (76/769/EEC) are either implemented through individual orders or through the Danish statutory order no. 1042 of 17 December 1997 on restrictions on the marketing and use of certain dangerous substances and preparations for specific purposes, latest amended 22 April 2000. The order also covers national provisions. Moreover, Denmark has issued strictly national provisions restricting certain other chemical substances and products.

Examples of amendments regarding the main EC *Restrictions Directive* (76/769/EEC) implemented by individual orders, include:

- Ban against import of certain Nickel-containing products (94/27/EEC)
- Ban against sale, import and manufacture of Cadmium containing products (91/338/EEC)
- Order on PCB, PCT and substitutes (85/467/EEC)
- Order on restriction in sale and use of pentachlorophenol (91/173/EEC)

Examples of amendments regarding the main EC *Restrictions Directive* (76/769/EEC) implemented by the Danish statutory order no. 1042 of 17 December 1997, include:

- Benzene: This substance is not permitted in toys or parts of toys as placed on the market where the concentration of benzene in the free state is in excess of 5 mg/kg of the weight of the toy or part of the toy. Benzene must not be used in concentrations equal to or greater than 0.1 % by mass in substances or preparations placed on the market (82/806/EEC).

- Arsenic: Arsenic compounds may not be used for antifouling, preservation of wood, or for the treatment of industrial waters irrespective of their use (89/677/EEC).

- Mercury: Mercury compounds may not be used for antifouling, preservation of wood, impregnation of heavy textiles, or for the treatment of industrial waters irrespective of their use (89/677/EEC).

- Chloroform, tetrachloromethane, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,1,2-tetrachloroethane, pentachloroethane, 1,2-dichloroethyleneor 1,1,1-trichloroethane: These substances, or products containing them, in concentration of more than 0.1 % w/w must not be placed on the market for sale to the general public and/or in diffusive applications such as in surface cleaning and cleaning of fabrics. Preparations with a higher content must be labelled "For industrial installations only"

[92]Published in OJ 1980 L 246 p.1.

(96/55/EEC).

Denmark has, in addition to the substances mentioned here, restricted or banned a number of other substances, e.g. ozone depleting substances, and '*Ae*'-substances as well as 'very toxic' and 'toxic' substances in consumer products. In some cases, stricter rules are applied compared to the EU requirements, e.g. in relation to asbestos, PCP, cadmium and creosote (DEPA, 1999).

It should be noticed that Denmark considers the main EU directive (76/769/EEC) a 'minimum directive', but this opinion is not shared by the other Member States.

<u>Examples of orders regarding strictly national provisions, include:</u>

- Ban against sale and use of certain products containing lead
- Ban against certain ozone depleting substances
- Order on cadmium in fertilisers
- Order on propellants and solvents in aerosol containers.
- Limitation of formaldehyde in chipboards, etc. used for furniture, equipment, etc.
- Ban against sale and export of mercury and mercury-containing products.
- Labelling and restriction of import, sale and use of surface treatment products.
- Ban against phthalates in toys for children aged 0-3 years.

In 1989 Denmark introduced national legislation limiting the permitted release of nickel from metal objects intended for close contact with the skin, such as earrings, spectacle frames and buttons.

In two comparable studies carried out in 1985-86 and 1997-98, the focus was among other sensitisers on the frequency of nickel sensitisation in persons of various ages.

Sensitisation to nickel was the most common in both studies. In 1985-86, 13,8% of the patients tested had positive reactions to nickel compared to 15% in 1997-98. Nickel allergy was four to five times more frequent among women both in 1985-86 and in 1997-98.

Nickel allergy is caused by close repeated skin contact with objects that release nickel. Nickel-plated jewellery especially earrings play a major role in nickel sensitisation.

Among children aged 0-18 years, nickel allergy decreased significantly from 24,8% to 9,2% from the first to the second study. No significant changes in nickel allergy were seen in the age groups above 18 years. This decrease is explained as the initial effect of the nickel exposure regulation, while an increase or unchanged prevalence would be expected in the older age groups.

Frequency of nickel allergy in studies carried out in 1985-86 and in 1997-98

Age groups	1985-86	1997-98
> 50	6,9%	7,9%
41-50	8,8%	17,7%
19-40	15,8%	19,9%
0-18	24,8%	9,2%

(Source: British Journal of Dermatology 2000; 142; 490-495)

Since the 1980s, the consumption of heavy metals has successfully been cut by 99 percent, and on Danish consumption of ozone layer depleting substances, for which consumption has fallen by 50% over the last decade, and on certain organic compounds such as PCP.

Cosmetic products

Cosmetic products have been regulated in Denmark since 1961. The EU directive on cosmetics, which was adopted in 1976, is intended to ensure that cosmetics are not harmful to consumers under normal use. The EU regulations are implemented with the Danish Statutory Order no. 594 of 6 June 2000 on cosmetic products.

The content of chemical substances in cosmetic products are regulated in three different ways:

- The responsibility for the safety of the products rests as a general rule with the manufacturer/importer
- Through negative lists of banned substances and products
- Through positive lists of allowed substances and products, which may be used as colouring agents, preservatives and UV-filters. These positive lists also include certain restrictions for use, limit values and/or time limits. All other substances for the mentioned purposes are banned.
- Through a list limiting or regulating the use of certain other substances, e.g. limitation in the type of products for which the substances are allowed, limit values and/or labelling criteria.

Denmark has with varying success suggested more stringent rules to be included in the adaptations to the directive. Currently Denmark is working to improve the requirements on ingredient labelling by including of fragrance allergens. Because of the known risk of allergy related to some perfume compositions, Denmark has now urged the Commission to consider a requirement for declaration. As of now, perfume and aromatic compositions are only referred to as 'perfume' and 'flavours'.

Cosmetic products must be registered with DEPA, mainly with information identifying the manufacturer or the person/company responsible for marketing the product and the product. The manufacturer is in addition obligated to submit additional information upon request from the Competent Authority, DEPA.

Toys

The EU directive on toys was issued in 1988 and uses a regulatory approach called 'the new method'[93], which implies that detailed regulation is exempt from discussions in the Council as well as in the Commission. Instead the private European standardisation organisations, CEN/CENELEC, are charged with the task of filling out the general rules in the directive.

The provisions regarding safety of toys have been implemented by the Danish National Consumer Agency through the Regulation on safety requirements for toys and products which due to their outward appearance may be mistaken for food (DNCA, 1995). This regulation is issued in agreement with the Ministry of Housing and Urban Affairs, the Ministry of Environment and Energy, and the Ministry of Health. In Denmark, DEPA administers the part of the control, which relates to the chemical properties of toys.

---

[93] The decision-making process in relation to the 'new method' involves very technical discu s-sions in working groups and implementation of the regulations as a Commission Dire ctive.

In particular, for the protection of children's health, bioavailability resulting from the use of toys must not exceed the following levels per day:

Chemical substance	**Maximum bioavailability**
Antimony	0.2 µg
Arsenic	0.1 µg
Barium	25.0 µg
Cadmium	0.6 µg
Chromium	0.3 µg
Lead	0.7 µg
Mercury	0.5 µg
Selenium	5.0 µg

In addition, toys must not contain dangerous substances or preparations within the meaning of the Substance Directive and the Preparations Directives (67/548/EEC and 88/379/EEC) in amounts, which may harm the health of children using them. At all events, it is strictly forbidden to include, in a toy, dangerous substances or preparations if they are intended to be used as such while the toy is being used.

DEPA has in March 1999, as mentioned in 10.2.6, issued a statutory order prohibiting the use of phthalates in toys for children under three years of age and certain childcare articles.

Pesticides (plant protection products and biocides)
Pesticides are divided in two main groups depending on their application:

One main group is called plant protection products, used particularly in farming, forestry, and horticulture and gardening as herbicides (weed killers), insecticides and fungicides. This group also includes microbiological products that consist of living micro-organisms (bacteria or viruses). It also includes plant growth regulators.

The other main group is biocides (non-agricultural pesticides), which among other things, are used to preserve wood, against insects and fungi in buildings and on livestock and pets, and to exterminate rats and mice. Biocides also include repellants and attractants. In the EU, biocides are regulated separately through the new Biocidal Products Directive.

Plant protection and also biocidal products are made up of one or more so-called active ingredients - the substances effective against one or more pests. In addition, such products can consist of various additives, auxiliary products, solvents and water.

In Denmark, the Plant Protection Directive and the Biocidal Products Directive are implemented in Danish law through Act on Chemical Substances and Products, latest amended through Act no. 256 of 12 April 2000, and the Statutory Order on Pesticides, latest amended on 5 May 2000 through Order no. 313. These amendments have been made in order to implement the Biocidal Products Directive.

The legislation on pesticides is fairly complicated. The main rules concerning approval of products are set out in Chapter 7 of the Chemicals Act, though other rules in the law apply to pesticides too. The most important rule in the law on pesticides is contained in Section 33, subs. 1, which sets out that, prior to their sale, import or use, pesticides must have been approved by the Minister for Environment and Energy. Any infringement of this rule is punishable in accordance with Section 59 of the Act.

In parallel with the Act, the executive order on pesticides is issued, containing a large number of specific directions and stipulations for pesticide manufacturers, importers, dealers and users.

As provided for in the Act, a series of separate executive orders and regulations are also issued, including one on a full or partial ban on the sale and use of certain pesticides, one on the classification, packaging, labelling, sale and storage of chemical substances and products, one on instructing commercial users and one on aerial spraying.

Approval of pesticides

A pesticide may not be imported, sold or used in Denmark unless the product involved has been approved by the Minister for Environment and Energy.

Applications for approval are submitted to DEPA on special forms by the party wishing to import or market a pesticide in Denmark - even where the product involved is identical with one already approved in Denmark (a parallel product). All information needed for an in-depth evaluation of the active ingredient and the product is submitted together with the application forms.

Above all, the approval - which is also called registration - includes a detailed evaluation of the environmental and the health effects of the active ingredient and the product in the area of use specifically being applied for, the choice of crops, the application season, product dosage, application method and so on.

In addition, the product is required to be efficacious for the application specified; it is decided whether using the product poses a risk to bees; treatment time-limits (spraying deadlines) are stipulated so as to eliminate the risk of product residues in foods, animal products (meat, eggs and milk) and feed, and the contents of the label are finalised.

The establishment of limit values for concentration in food forms part of this approval. Where substances are approved for use, a Maximum Residue Limit MRL is laid down, specifying the maximum acceptable residue concentration of the pesticide or its degradation products or metabolites.

The limit value in food products is based partly on a toxicological evaluation of the health risks presented by intake of the pesticide, specifying an Acceptable Daily Intake (ADI), and partly on the residue concentrations in vegetable food of the pesticide found after use of Good Agricultural Practices GAP. GAP is defined as the nationally authorised applications, which under current conditions are required to efficiently combat harmful organisms.

When establishing the MRL the health aspect ADI is combined with the use of the pesticide in question GAP. This is done by combining the ADI with the theoretic maximum daily intake MTDI, calculated by means of cost models, assuming that all crops on which the pesticide can be used contain the maximum acceptable concentration of the pesticide. In order to establish the limit value, the TMDI shall not exceed the ADI. In Denmark, the limit values for food are laid down by the National Veterinary and Food Agency.

Approvals are generally operative for up till ten years for plant protection products and biocides, but if a product is classified as "very toxic" or "toxic" to humans, the approval expires after just five years. If it is wished to keep up the approval, an application to renew the approval must be made at least one year before the existing approval expires.

Targets

The reduction targets for agricultural pesticide consumption can be found in the Minister for the Environment's Pesticide Action Plan II from March 2000. This action plan is based on the work performed by The Pesticides Committee (Bichel-committee) who have evaluated the overall consequences of phasing out agricultural pesticide consumption over a period of ten years. The committee's report was published in March 1999.

The committee estimated that the total average load of pesticides from food and drinking water reached approximately 1% of the ADI. They concluded that it was not possible on the basis of epidemiological data to prove that exposure of the general public, e.g. through food, constitutes a health risk.

Based on the evaluation, the committee suggested that a number of investigations were effected, among others related to the potential health impact of pesticides.

Example 3 Contribution margin by different pesticide uses.

The analyses are based on a set of scenarios, aiming at clarifying the consequences of different levels of restrictions on the use of pesticides in agriculture. The point of departure for setting up the scenarios was the aim of clarifying the impact of total phasing out the use of pesticides. However, also the impact of less restrictive policies is analysed.

The purpose of including the less restrictive scenarios in the analysis is to clarify the relation between pesticide use, production and economy, during different treatment intensity, in order to get a better picture of the consequences of different levels of phasing out the use of pesticides in agriculture. The analyses are made at operational level only. The agronomical premises were specified on the basis of both technical/biological research and managerial economy research. As is the case with the key scenarios, the analyses are based on the operational model (DØP).

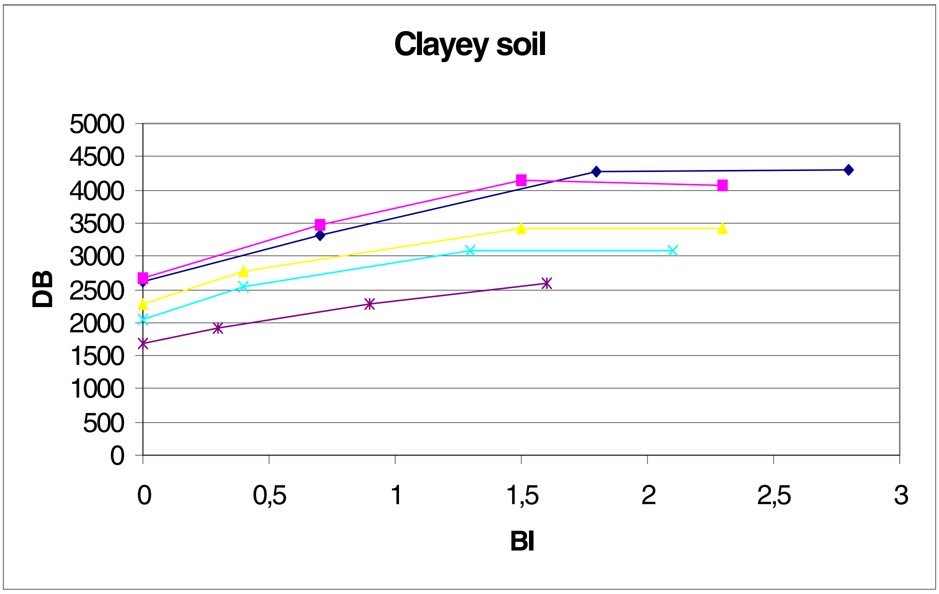


FIGURE 10.2 THE CONTRIBUTION MARGIN BY DIFFERENT PESTICIDE USES (TREATMENT FREQUENCY) CLAYEY SOIL
SOURCE: ØRUM (1999)

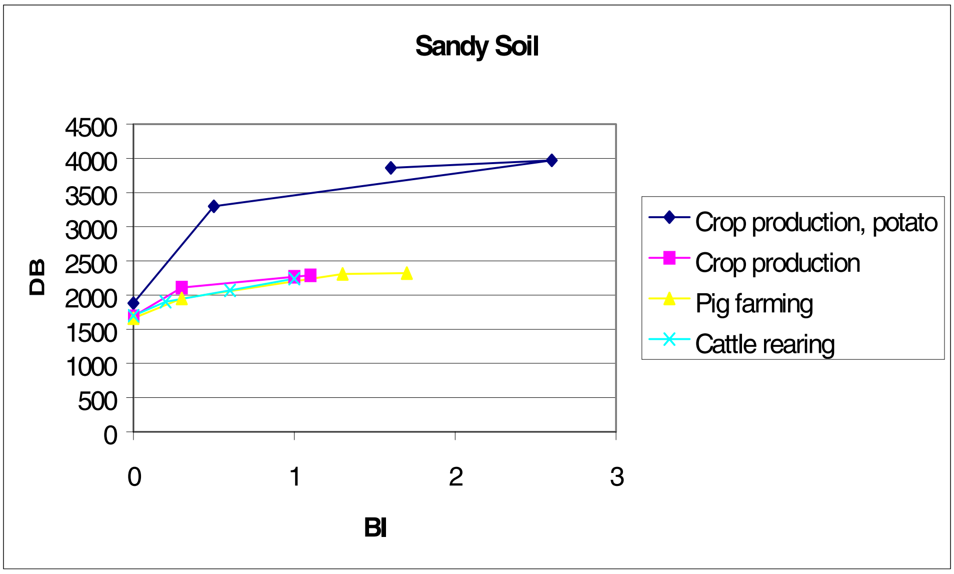


FIGURE 10.3 CONTRIBUTION MARGIN BY DIFFERENT PESTICIDE USES (TREATMENT FREQUENCY) SANDY SOIL[94]
SOURCE: ØRUM (1999)

Biocidal products
As mentioned above, rules pertaining to biocides (disinfectants, preservatives, wood preservatives, rodenticides etc.) have been established through the new *Biocidal Products Directive* (EC, 1998). The purpose of the directive is to ensure that all chemical and microbiological products intended to kill biologi-cal life are approved before use. Product categories like medicinal products, cos-

[94] The unusual course of the crop production and the potato curves indicates that small changes in the composition of the production may cause considerable effects on pesticide treatment.

metic products, veterinary medicinal products, and plant protection products, which already fall under the scope of an approval scheme, are exempted from the scope of the Biocidal Products Directive.

Many biocides are not particularly specific, for which reason there is a great risk that they can affect living organisms other than those they are intended to target. Moreover, the use of many biocides is widespread, which means that a large part of the population uses them or is in contact with them daily. Biocides are also directly and indirectly discharged into the environment. On the European market, this relates to products that contain any of a total of about 1,000 active ingredients and which shall be subjected to a restrictive approval procedure. Only a portion of the biocides has been covered by the previous Danish scheme for the approval of pesticides.

The Biocidal Products Directive has now been implemented in Danish law through the Act no. 256 of 12 April 2000 amending the Act on Chemical Substances and Products and the Statutory Order on Pesticides, latest amended on 5 May 2000 through Order no. 313. A transitory period has been introduced for biocides in the amended legislation. The active substances are divided into 4 main categories covering 23 product types in total. The directive distinguishes between common EU-decisions on active substance level and national decisions on preparations. The substitution principle also apply to biocides and thus an active ingredient can not be included in the annex of approved ingredients if a better alternative exists.

International co-operation

Part of DEPA's strategy aims at strengthening international co-operation in the field of chemicals. Denmark already cooperates on several levels, the Nordic level under the auspices of the Nordic Council of Ministers, the EU level and globally under the auspices of the UN.

Conventions

Transboundary pollution by dangerous chemicals and the increased international trade in chemical substances and products mean that there is a need for an effective effort, to minimise the risk to the environment and health at the global level. Three important conventions in this area are the POP-convention, the PIC-procedure and the Montreal-convention.

POP-convention

In 1997, UNEP Governing Council asked UNEP to establish an International Negotiating Committee (INC) in order to prepare a legally binding instrument with the aim to reduce and/or eliminate the environmental problems caused by Persistent Organic Pollutants (POP). The aim of the POP Convention is to prohibit the production and use (and possibly import and export) of 10 identified POP substances. In addition, the POP Convention aims to prevent, reduce and as far as possible eliminates emissions of 2 identified POP by-products. The 12 substances are all persistent in the environment, they are transported over long distances and far away from the sources and they bioaccumulate in the majority of living organisms.

Denmark has given the POP negotiations high priority. It has been important for Denmark to signal that the agreement of a global POP Convention is necessary in order to minimise and eliminate the environmental effects from the 12 hazardous chemicals. There are numerous important articles in the draft POP Convention as it stands. The prohibition of production and use of POP pesticides as well as the continuing minimisation and ultimate elimination of emissions of dioxins and furans are examples of the most important obligations.

The signature of the POP Convention is expected to take place at a diplomatic conference in Stockholm in May 2001.

PIC-procedure (Prior Informed Concent)
PIC is a procedure that helps participating countries learn more about the characteristics of certain hazardous chemicals before they are shipped to them. The PIC initiates a decision making process on the future import of these chemicals by the importing countries themselves and facilitates the dissemination of this decision to other countries. The aim is to promote a shared responsibility between exporting and importing countries in protecting human health and the environment from the harmful effects of certain hazardous chemicals which are traded internationally.

The PIC-procedure currently includes 24 pesticides and 5 industrial chemicals that are banned or severely restricted in a number of countries and which should not be exported without the concent of importing countries. The aim of the procedure is not to ban or restrict the chemicals on the list, but to alert the importing countries to the dangers of the chemicals. Previously, the PIC procedure was voluntary, but in September 1998 it was turned into a legally binding procedure, i.e. the Rotterdam Convention.

Montreal-convention: Ozone depleting substances
Denmark has actively participated in the international work on substances that deplete the ozone layer. In 1997, the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted. Governments recognised the need for measures to reduce the production and consumption of a number of ozone depleting substances. The Protocol was designed so that the phase-out schedules could be revised, which actually has taken place 5 times since 1987. The results achieved so far indicate a success story for international ozone initiatives. The used amount of ozone depleting substances has decreased dramatically and agreements have been reached to phase out all ozone depleting substances. The Montreal Protocol is now seen as a model for other international environmental treaties.

On the national arena, Denmark prepared in 1988 an action plan on reduction of the consumption of ozone depleting substance. The plan provided for a combination of instruments, including bans and economic instruments such as taxes and a development programme. Part of the plan was also to phase out the ozone depleting substances as soon as possible and the result has been, that Denmark has stopped the use of the substances quicker than other parties to the Montreal Protocol. These experiences have been used on the international arena under the Protocol in order to strengthen the phase out dates both in the EU and the UN.

TBT-convention (International convention on harmful antifouling systems)
Since 1998 a convention on harmful antifouling systems has been negotiated under the auspices of the United Nations, i.e. in the Environmental Protection Committee (MEPC) under the International Maritime Organisation in London.

The aim of the convention is to reduce or eliminate adverse effects on the marine environment and human health caused by antifouling systems. e.g.

chemicals with a biocidal effect. Antifouling systems are used on ships to prevent a wide variety of sea organisms to stick to the ships' hull and thus negatively impacting the ship.

The first antifouling system that will be banned according to the convention are all the organotin compounds, of which TBT is the most well-known. The negotiations in the MEPC are centred on two years: 2003 and 2008. By 2003 is shall no longer be allowed to paint the ship with paint that contains TBT, whereas from 2008 the TBT ban shall be final, i.e. TBT may no longer be part of the ship's active anti-fouling system, not even if the TBT paint was applied to the ship prior to 2003.

Denmark strongly supports the phasing out of the organotin compounds. However, Denmark is also stressing that adding more systems/substances to the negative list is a very important part of the convention. Should another antifouling system than the TBT-based paints turn out to cause unacceptable adverse effects, the rules and procedures for how to achieve global agreement on the banning or restriction of that antifouling system will already be in place, thus allowing authorities to take action.

The convention is expected to be signed at a diplomatic conference in London in October 2001.

Reporting to the Danish Register of Substances and Products

The product register, which was established as a joint register for DEPA and the National Working Environment Authority (NWEA), contains information on the composition of, and other information on, a number of chemical products that contain dangerous chemical substances, most of which are used commercially. The substances and products which must be registered are those which are used industrially and fall under the concept of danger applied by the NWEA. This concept is somewhat broader than that of DEPA, which only cover classified substances and preparations. NWEA's concept also includes volatile organic solvents, epoxy and isocyanates and substances considered carcinogenic by NWEA. Thus, a number of chemical products are not covered by the rules on reporting to the Register. This applies, for instance, to certain detergents and cleaning products, together with certain paint and varnish products, which are not subject to classification or which are sold only for private use. Cosmetic products shall, however, be reported to DEPA, although such reports do not include information on the component substances of these products.

10.3.5 Instruments

DEPA uses a variety of policy instruments to implement the chemical policy through influencing people's behaviour. Most of these instruments are elements in DEPA's product-oriented environmental strategy. This strategy focuses on improvement from the standpoint of the health and environment of products (goods), considered over the entire life-cycle of such products and, therefore, on reducing the use of chemical substances in the manufac-turing and use of the products.

Integrative instruments

Green guidelines for purchasing

DEPA supports the development of a market for greener products by furthering an increased and more qualified demand for cleaner products. The demand for greener products may come from targeted information to consumers and professional purchasers.

DEPA has issued a number of guidelines for a whole range of products and services including e.g. clothes, furniture, office equipment, buildings and transport. The purpose is primarily to support public purchasers in buying the most environmentally friendly products and services. The documentation, which forms the background for the guidelines, does however also contain an evaluation of the health impact of the products and services.

Regulatory instruments

Action plans
DEPA has issued a number of action plans related to selected chemicals aiming at reducing or phasing out the substances to health and environment both in Denmark and internationally. Such action plans have been prepared for e.g.:

- Brominated flame retardants
- Phthalates in flexible PVC
- Pesticides
- Ozone depleting substances
- Heavy metals

List of undesirable substances
In 2000, DEPA issued an updated "List of Undesirable Substances". The list of about 100 substances, or groups of substances, is a signal to manufacturers, buyers, product developers, etc., that they should consider substitution. The list gives special priority to 26 substances, which the authorities wish to see restricted or completely banned. The special priority assigned to these substances is an advance warning of where DEPA will concentrate its efforts. The List of Undesirable Substances forms the foundation for a number of initiatives over the coming years. These initiatives include prohibition or restriction, phasing out, EU risk assessment, classification, national surveillance programmes and scientific studies.

Today, a sufficient body of knowledge already exists on some of the listed substances to enable the start of restriction initiatives, whereas additional knowledge is needed on other listed substances before any restrictions can be implemented. For the remaining substances, initiatives have been taken in the EU to conduct risk assessments and to implement any consequent restrictions on use.

The new version of the List of Undesirable Substances issued in 2000, was revised against the background of updated information on consumption quantities stored in the Product Register. In the new list, potential candidates from the List of Effects[95] are included. Among the health-based selection criteria for the list of undesirable substances are classification for health effects (high acute or chronic toxicity, CMR effects or allergy), specific concern in relation to the use of the substance, and substances targeted for phasing out. Other criteria include environmental effects, also calculated using QSAR

[95] The List of Effects is the gross list of about 1,000 substances, which the DEPA has identified while drafting the List of Undesirable Substances. The substances on the List of Effects possess properties that are just as undesirable as those of the substances on the List of Undesirable Substances, although they are only used in smaller quantities.

modelling, consumption on the Danish market of more than 100 tonnes, and substances which are problematic in the aquatic environment, in waste disposal and in the ground water.

Some of the high priority substances for phase out initiatives or a targeted effort to increase the knowledge base are:

- alkylphenols
- alkylphenol ethoxylates (miscellaneous applications)
- azo dyes, selected
- chromium compounds
- dichloromethane
- formaldehyde
- copper compounds
- organotin compounds

Voluntary agreements
Voluntary agreements between authorities and chemical producers/importers have come into use in recent years, especially in the 1990s. Such agreements have been initiated in relation to e.g. the so-called VOC-chemicals, i.e. volatile chemical hydrocarbons. These hydrocarbons are regularly found as air pollutants evaporated from motor fuels during transportation, relocation or handling. The use of nonylphenol ethoxylates in cleaning agents is another example of a voluntary agreement between DEPA and the Trade.

Organisation for Soap, Perfume and Toiletries entered in 1987. A third example is the agreement regarding nonylphenols in pesticide formulations. This agreement entered into force in 1995 and the phase out was finalised in 2000. More than 100 products containing nonylphenols and nonylphenol ethoxylates have been phased out.

Economic instruments

Taxes
Denmark has introduced taxes on a number of chemicals. These include:

- Pesticides
- Lead batteries and sealed nickel-cadmium batteries
- Chlorinated solvents
- Nitrogen in fertilisers
- PVC and phthalates

These taxes are meant to influence the behaviour of enterprises and of individuals. The purpose is to promote substitution and to reduce the use of chemicals and thereby their occurrence in the different media, soil, water and air and possible exposure on humans.

Subsidies
DEPA has launched a 'Programme for cleaner products' in 1999, which is a subsidised programme with the purpose of strengthening the development and sale of cleaner products. Projects, which are supported must explicitly aim at preventing the environmental impact from all phases in the life cycle of the products or the services. Many of the subsidised projects also focus on the health impact of the products and services.

Information and other instruments
The public sector is under special obligation to lead the way in areas that the government wishes to promote. Increased stable demand for less environmentally degrading goods and services is considered an essential incentive for manufacturers and importers to market cleaner products. Focus in the purchase guidelines is on environmental aspects, but also general health aspects and health in relation to the working environment is taken into consideration in the background information.

Eco-label
Eco-labels are important instruments designed to give the public necessary information for making an environmentally friendly choice. The Nordic swan and the EU-flower are the two official eco-labels for chemical preparations and goods in Denmark. There are no other officially accepted eco-labels in Denmark. The eco-labels are regarded as a tool to minimise the environmental impact from products, to be used in connection with the reduction of consumption as part of the Cleaner Products strategy. The Eco-labels do not specifically focus on health aspects, but they do include criteria related to the protection of health. As an example the EU flower can not be assigned to substances or preparations which are classified as very toxic, toxic, carcino-genic, toxic to reproduction, or mutagenic or to goods which have been manufactured by processes, which can cause considerable harm to man or to the consumer in general.

Fact sheets
DEPA has started to prepare easily-understandable information on statutory orders issued under the Chemical Substances and Products Act. This material is entitled "Fakta om kemi" ("Facts on Chemistry", only in Danish) and the target groups are consumers and retailers, together with minor importers and manufacturers. "Facts on Chemistry" are distributed by DEPA and are also available on DEPA's home page (www.mst.dk).

Other information material
In addition to the fact sheets, DEPA publishes different types of information material for consumers, industry and the scientific sphere explaining regulatory requirements, giving advice or adding to the general level of knowledge. This material includes leaflets, brochures, magazines, guidelines and scientific reports.

On the DEPA homepage, a large amount of information about chemicals is available. This includes factual information about chemicals, articles and goods, as well as legislation and scientific reports from DEPA.

It is also possible to contact DEPA and ask specific questions about chemicals using the "chemistry phone" which is administered by The Chemical Inspection Service (CIS).

10.4 Actors

The administrative responsibility for chemicals and chemical pollution rests with several different ministries. These include the Ministry of Environment and Energy, the Ministry of Food, Agriculture and Fisheries, and the Ministry of Health and the Ministry of Labour. Other less directly involved ministries are the Ministry of Housing and Urban Affairs, the Ministry of Social Affairs and the Ministry of Education and Research. Furthermore, the regional councils also play an important role in protecting the environment against the effects of chemical substances and products.

Actors involved directly in the administration of DEPA' s regulation and efforts in the chemical field are listed in the following table.

Table 10.2 Actors, roles and responsibilities concerning chemical regulation

Actors	Roles and responsibilities concerning chemical regulation
The Danish Environmental Protection Agency (DEPA)	The administration of the Chemical Substances and Products Act is centralised in DEPA and very little authority in this area is delegated to the local authorities. The reason for this is that the area demand high specialisation. DEPA administers the act and is responsible for negotiations at the European and international level.
Chemical Inspection Service	The Chemical Inspection Service (CIS) of the DEPA carries out supervision to ensure compliance with the rules and rulings in pursuance of legislation on chemicals. This effort focuses particularly on areas of essential importance to health and the environment, areas where requirements differ from the rest of the EU, and imports from non-member countries. Violations of the Chemicals Act and the majority of the statutory orders are punishable by fines, simple detention or up to two years' imprisonment unless more severe punishment is due in accordance with other legislation.
The Danish Veterinary and Food Administration	Institute for food safety and toxicology assists DEPA in the area of research, risk assessment and development of health based criteria applied in the regulations.
The medical officer on health	The medical officers on health play a very central role locally concerning health aspects of chemicals where they advise counties and municipalities. They are in close contact with the central health and environmental authorities.
Counties	-
Municipalities	-
Local Councils	The local councils help DEPA to enforce retailer compliance with the labelling and storage rules.
The National Working Environment Authority	In its capacity of workplace supervisor, the Working Environment Authority reports any violations of the labelling and storage rules to DEPA..

10.5 Evaluation

One of the main objectives of chemical regulation in Denmark is to prevent health hazards caused by the use of chemicals in society. A second objective is to promote the use of less health hazardous chemicals through application of cleaner technologies and various instruments restricting the use of certain chemicals or supporting the choice of more safe chemicals for both professional use and for consumers.

Chemical substances form part of daily life in modern societies, also in Denmark. They are used in agricultural and industrial production, and in private households. Knowledge about to what extent the use of chemicals affect public health is relatively sparse, both in relation to individual substan-ces and in relation to the combined pressure from different sources. In some areas, a certain level of knowledge is available, e.g. from reporting of acute toxicity cases to emergency sections at hospitals and the poison control centre. Workplace exposure and related effects is another area contributing to the general knowledge about the possible impact on private users, especially when it comes to acute effects, but also in relation to e.g. development of eczema and other allergic diseases.

Knowledge about the effects of long-term exposure and chronic effects in general is however very limited, as it is extremely difficult to relate the use of various chemicals to the incidence of cancer, reproductive toxicity, allergy and other chronic effects and because little is known about the actual level of exposure to chemicals. A vast number of confounding factors are involved, including factors mainly attributed to the life-style of people like smoking and eating habits, which may add to the same adverse effects.

As the regulation of chemicals is based on the existing level of knowledge, a major concern in relation to industrial chemicals is the large number of substances for which there is insufficient information with regard to hazardous properties. Substances which are not fully investigated and not yet on the market may appear as not problematic. Only for chemical substances and preparations, which are covered by an approval procedure before they are marketed, it is ensured that the substances are properly investigated. In addition the regulation on classification on labelling only considers the hazardous properties of the chemicals which means that possible critical uses of the chemical are only regulated and limited when specific use restrictions have been introduced. Another aspect, which needs to be further addressed in the regulations, is the protection of vulnerable groups. In this respect, especially exposure to pregnant women (and thereby exposure to the unborn child) and children should be considered as these groups may either be more susceptible towards chemical exposure or in some cases more exposed. Today, we know that especially the foetus undergoes different periods of development in which susceptibility for adverse effects from exposure to specific chemicals may be increased.

The quantities of chemicals in use are growing violently - solving some problems, but also causing adverse effects relating to health and environment. Consumers and interest groups are making increased demands with regard to the safety of products, which are marketed. At the same time it is expected that the authorities have the market under control and are able to react quickly and efficiently with new regulation in order to guarantee a high level of protection of the public.

A major challenge in chemical regulation is therefore the procurement of information about the many substances, which are not sufficiently investi-gated, and the identification of the problematic substances. In this respect, DEPA supports the work using computerised QSAR-modelling for predicting inherent properties for substances, which have not been adequately tested. Unwanted effects like endocrine disruption also need to be more directly addressed in the regulation, as it is suggested that exposures of vulnerable groups to tiny amounts of endocrine disrupting chemicals may result in serious adverse effects especially in relation to immunotoxic, neurotoxic, reprotoxic or carcinogenic endpoints. In addition there is a need for an effort in relation to exposure assessment in specific fields of application resulting in *high exposure* of the public or *considerable spreading* of the substance.

According to the Danish Government there is also a need for a more comprehensive revision of the European chemical regulation, which forms the background for most of the Danish regulation, among other things to speed up the process with regard to risk assessment and identification of problematic substances. Furthermore, the reversion of proof, is an important subject that may promote the protection of the population. Today the chemicals are often considered as harmless unless there are data showing the opposite. In future the goal is to make the industry responsible for presenting data to document the safety of the chemicals.

In order to achieve a higher level of protection of human health, a number of areas have been identified which should be subject to intensified efforts and also generation of more knowledge. The following areas may serve as examples of the goals of such intensified efforts:

- To achieve a higher level of protection of the population through prevention of use situations resulting in high exposure.
- To increase the protection of vulnerable groups (e.g. children) through limitation of their exposure to chemical substances and to regulate the use of substances which are particularly problematic to the health.
- To reduce to the unintentional spreading of chemicals in products and in the environment in order to avoid diffuse exposure routes.
- To protect the health by demanding that the industry documents the safety of chemical substances in use.
- To increase the level of protection through a reduction in the number of non-assessed chemical substances using QSAR-evaluation of these chemicals, both for regulatory purposes and screening purposes in relation to further testing. Furthermore to use group evaluation of substances to a greater extent instead of only assessing the individual substances.
- To prevent the use and spreading of endocrine disrupters.

10.6 References

Literature

British Journal of Dermatology (2000).

COM (1999): "*Communication from the Commission to the Council and the European Parliament: Community strategy for Endocrine disrupters - a range of substances suspected of interfering with the hormone systems of humans and wildlife*". Brussels, 17 December 1999.

Danish National Consumer Agency (DNCA): "*Regulation no. 329 of May 23 1995*". Regulation on safety requirements for toys and products which due to their outward appearance may be mistaken for food.

DEPA (2000): "*More about chemicals*", Danish Environmental Protection Agency 27/03/00, DEPA Homepage.

DEPA (2000): "*Listen over uønskede stoffer*". (List of undesirable substances). Orientering fra Miljøstyrelsen Nr. 9, 2000.

DEPA (1999): "*A strategy for intensified efforts in the field of chemicals in Denmark, in the EU and globally*." January 1999, DEPA Homepage.

DEPA (1999): "*EU, Danmark og miljøreglerne*". (EU, Denmark and environmental regulation). Arbejdsrapport nr. 7, 1999.

DEPA (1996): "*Chemicals – Status and Perspectives. Excerpts from a discussion paper from DEPA, English Summary and List of Undesirable Substances*".

European Chemical Bureau.(2000): *IUCLID CD-ROM, Year 2000 Edition, Public data on high volume chemicals*. EUR 19559 EN. European Commission Joint Research Centre

http://www/agrsci.dk Exposure model

Ministry of the Environment and Energy (1995): "*Miljø- og naturpolitisk redegørelse 1995*" .Chapter 10 (Political statement on the Environment and Nature). ISBN 87-601-4898-5.

Ministry of the Environment and Energy, Ministry of Health, Ministry of Food, Agriculture and Fisheries, November 1999: "*Protection of children and pregnant women against dangerous substances*".

National Institute of Occupational Health (2000): "*Kemikalier og produkter i arbejdsmiljøet*" - *Kap. 2:* "*Klassificering og mærkning*". (Chemicals and products in the working environment. Chapter 2: Classification and labelling).

Nielsen, E. et al, 2000 (draft): "*Children and the unborn child: exposure and susceptibility to chemical substances - an evaluation*". The Institute for Food Safety and Toxicology, Danish Veterinary and Food administration.

Danish legislation

Act on Chemical Substances and Products, cf. Consolidation Act no. 21 of 16 January 1996 and subsequent amendments.

Statutory order no. 1065 of 30 November 2000 on classification, packaging, labelling, sale and marketing of chemical substances and products.

Statutory order no. 1012 of 13 November 2000 on prohibition of import and marketing of products containing lead.

Statutory order no. 594 of 6 June 2000 from the Ministry of Environment and Energy on cosmetic products.

Statutory order no. 733 of 31 July 2000 on the list of dangerous substances, with amendments.

Statutory order no. 24 of 14 January 2000 from the Ministry of Environment and Energy on prohibition of import and sale of certain nickel-containing products.

Statutory order no. 151 of 15 March 1999 from the Ministry of Environment and Energy banning phthalates in toys for children aged 0-3 and in certain childcare articles etc.

Statutory order no. 241 of 27 April 1998 from the Ministry of Environment and Energy on pesticides, and subsequent amendments.

Statutory order no. 35 of 19 January 1998 from the Ministry of Environment and Energy on the Community and the Nordic eco-labels.

Statutory order no. 1042 of 17 December 1997 on restrictions on the marketing and use of certain dangerous substances and preparations for specific purposes, and subsequent amendments.

Statutory order no. 1002 of 14 December 1995 from the Ministry of Environment and Energy on notification of new chemical substances.

EU legislation

See Appendix 6.

11 Waste

Waste is a by-product of human activity and is defined as any substance or object that the owner discards, or intends or is required to discard (Framework Directive on Waste). Managing waste can cause impacts on the environment and human health. Problems can arise from the moment waste is produced to when material is recovered from waste, waste is converted into usable energy, or deposited at a landfill site.

Both the amount and the toxicity of waste can have an impact on the environment and/or human health. The challenge is therefore to stabilise or reduce the amount of waste generated, as well as minimise the detrimental impacts from hazardous substances in waste.

Waste has traditionally been perceived as useless and something to be disposed of at the lowest possible cost. However, poor standards of management, particularly some notorious episodes such as mercury poisoning of Minamata Bay, Japan in 1956 and chemical waste disposal at Love Canal, USA, in 1978 helped raise the public awareness of the consequences of poor waste management. The primary issues addressed by early waste regulation focused on the potential health risk posed by improper waste disposal and associated environmental impacts, and involved setting emission limits and standards in an 'end-of-pipe' approach. In parallel with increasing environmental concern and the introduction of concepts such as sustainability, the approach to waste management also changed. Today, waste is increasingly considered as representing a loss of resources and energy from the economy, and although 'end-of-pipe' control is still crucial, waste regulation now includes the entire waste management system, from production to disposal.

This chapter focuses on the regulatory framework on waste and the associated environmental factors that potentially have an impact on human health.

11.1 Human Exposure to environmental factors

Nowadays direct human exposure to waste is normally restricted to private production and disposal of waste and possibly also exposure in the working environment. In the 19th century and the first half of the 20th century, however, exposure to waste and wastewater was severely threatening public health. The driving force behind most of the present waste regulation has therefore been considerations for human health, and only in the last decades have considerations for the environment and resource efficiency have been included. The result is a waste management system with virtually no direct human exposure to waste, but with indirect exposure through emissions from waste management. These indirect health effects through contamination of air, soil or water are covered under the chapters addressing these media.

Examples of exposure to environmental factors from waste are given in table 11.1

TABLE 11.1 EXAMPLES OF EXPOSURE TO ENVIRONMENTAL FACTORS FROM WASTE

Environmental factor	Origin and characteristics	Potential Health Impact
Heavy metals e.g. lead, cadmium, mercury	e.g. NiCd batteries, lead accumulators, PVC, hazardous waste, foundry waste. Emissions from incineration plants, landfill sites and metal recycling plants.	Neurotoxic effects Suspected carcinogens
Organic pollutants e.g. PCB, dioxins, VOC	Hazardous waste, emissions from incineration plants, landfill sites, metal recycling plants etc.	Cancer Reproduction
Micro-organisms	Putrescible organic waste. Inhalation of aerosols	Gastro-intestinal effects and systemic infections.
Others e.g. NOx, CO, SO_2, HCl, HC, etc.	Combustible material, incineration plants, waste collection and transportation.	Respiratory effects (more details given in chapter 5 on individual factors)

11.1.1 General waste stream

Danish waste management streams from source to final disposal are presented in figure 11.1. The figure does not intend to present all possible waste streams, but merely to give an overall picture.

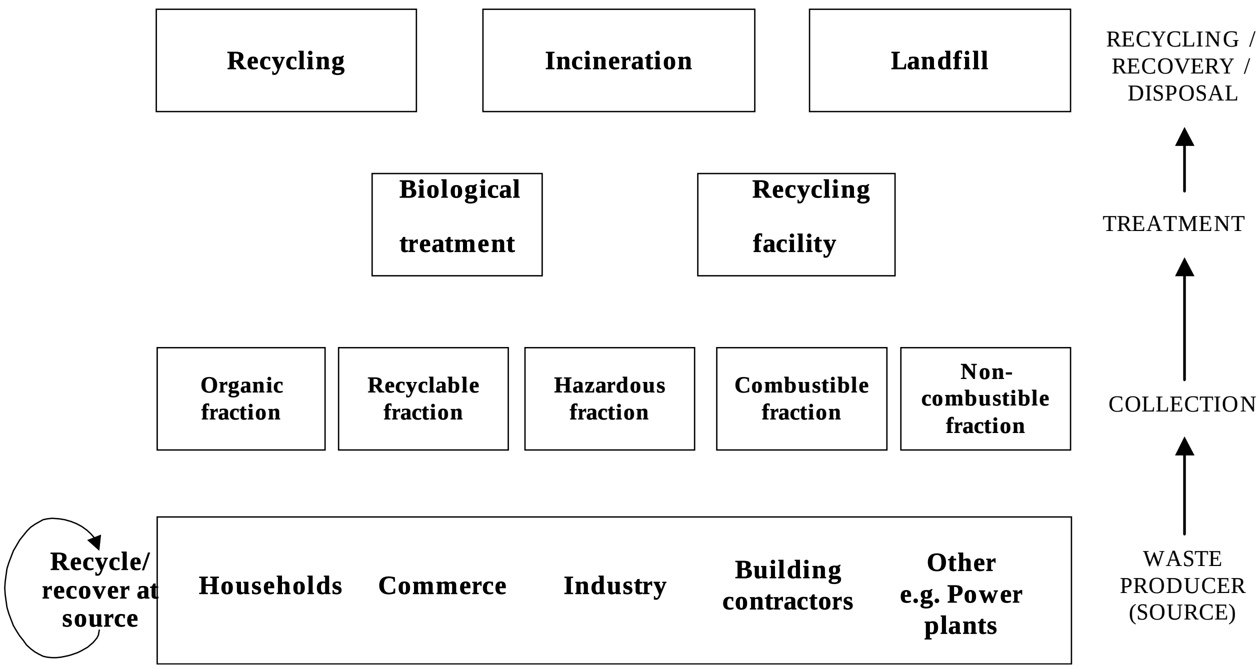


FIGURE 11.1 OVERALL PICTURE OF WASTE MANAGEMENT STREAMS FROM SOURCE TO FINAL DISPOSAL.

Waste production
For the waste producer, waste poses a potential health problem until it has been collected. Problems can include the spread of micro-organisms during the biodegradation of organic waste, odour, the presence of vermin and risk of disease spread, and the risk of physical contact, especially with discarded hazardous substances.

Collection and transport
Human exposure during waste collection and transport is associated mainly with transport. The large quantities of waste that are generated mean that the transport of waste constitutes a source of environmental factors such as emissions to air from waste collection vehicles of NO_x, SO_2, CO, particulates, and hydrocarbons (see Chapter 5 on air). In addition, transport of waste involves an inherent risk of accidental discharge of harmful emissions to the environment.

Waste composition
The environmental factors to which humans can be exposed depend on the waste composition. Waste streams containing hazardous substances pose a significant health risk. For instance, the separate collection and recycling of waste containing high concentrations of heavy metals can significantly reduce the environmental impact of incineration/landfill. Heavy metals are not destroyed during incineration and are either emitted from the incineration plant via the smokestack, in the wastewater, or in the residual waste. A reduction in the heavy metal content of waste incinerated would therefore result in lower emissions and lower health risk.

11.1.2 Waste treatment facilities

Waste treatment and disposal facilities can be considered as consisting of a series of input and output material and energy streams, as shown in Figure 11.2 below. Of concern from a public health viewpoint is exposure to the following outputs: emissions to air, soil and water, and residual waste. Emissions to the environment are a potential health risk, both when 'controlled' and discharged during routine operation of the waste facility, and when released accidentally. In addition to the outputs mentioned, waste facilities can give rise to exposure to environmental factors that can be a nuisance, such as noise, smell, and dust from the facility operations.

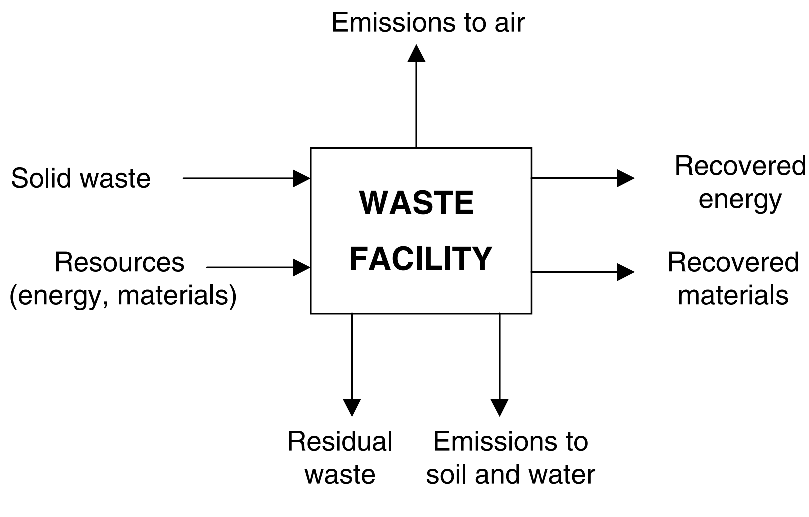


Figure 11.2 Input-output analysis or mass balance of a waste facility.

Examples of waste facilities including recycling facilities, biological treatment plants, incineration plants and landfill sites and the most important environmental factors associated with these facilities are given below.

Waste recycling facilities
In 1998, 62 % of the total amount of waste generated in Denmark was recycled[96]. Waste is recycled and treated at a number of Danish recycling facilities, e.g. steel mills, crushing facilities for construction and demolition waste, treatment facilities for hazardous waste, glass factories, paper factories and plastic factories. Emissions from the recycling facilities are primarily air emissions.

Biological treatment
The primary objective of biological treatment is to use the treated waste as agricultural fertiliser. Energy production may be the secondary objective in some cases. Provisions have been laid down on the use of compost, ash from biomass, sludge, sewage and other waste products for agricultural purposes (Statutory Order on Sludge no. 49 of 20 January 2000 and Statutory Order on Bioash no. 39 of 20 January 2000). These regulations define hygienic criteria as well as quality criteria for the maximum concentration of organic contaminants and heavy metals in waste products to be distributed on agricultural land. Fulfilment of these rather strict requirements is only possible through careful control of the waste composition including sorting out problematic fractions at the source.

Biological treatment can be used to treat the biodegradable fraction of waste, such as organic household waste and garden waste. Two main treatment types exist: composting and biogasification. Composting involves the aerobic degradation of organic matter in reactors or windrows. Possible health risks related to composting include emissions to air of e.g. aerosols containing microorganisms and endotoxins. The presence of vermin could also pose a health risk. Biogasification is an anaerobic process that takes place under controlled conditions in closed reactors and is mostly used in combination with liquid manure. The small amounts of leachate formed at composting plants and the liquid effluent from the biogasification process, which is used as fertiliser, are not thought to present a potential health risk.

Incineration plants
Emissions to air and water, and emissions related to residual solid waste are outputs from incineration plants that cause potential health risks. Contaminants emitted to air via the smoke stack include dioxins and furans, volatile heavy metals (e.g. Hg, Cd, Pb), acidic gases (HCl, HF, SO_2), and particulates, all of which pose a potential risk to human health. Exposure can occur either by inhalation or by ingestion following transfer of the emission to soil or water. Emissions to water result from discharges of wastewater from the flue gas cleaning process and can affect people in contact with the recipient water (e.g. stream).

Residual waste from incineration plants comprises bottom ash (or slag) and the more toxic residues from flue gas treatment. Bottom ash can be used in construction, e.g. as an aggregate in road base material. Flue gas cleaning residues are considered hazardous and need to be treated prior to disposal at a

[96] 10 % of the waste was exported, and the waste imported was a little over 4 % of the waste amount generated in Denmark (in 1998).

landfill for hazardous waste. Contaminants such as heavy metals (Cd, Ni, Cu, Zn, Pb) in residual waste including both bottom ash and especially flue gas cleaning residues can potentially leach resulting in emissions to soil and groundwater and/or surface water.

Landfill sites
The main outputs from landfill sites are landfill gas and leachate. Potential health risks from landfill gas relate to the migration of methane through the soil and into neighbouring houses, causing a potential for explosion. Other trace components in landfill gas such as volatile organic compounds are also a public health issue. At landfill sites with gas collection systems, landfill gas is recovered and used to generate heat, electricity or both.

Leachate can potentially contaminate the soil and groundwater surrounding the site, which poses a threat when this water is extracted for drinking purposes (surface water can also be affected). Leachate often contains harmful organic compounds (e.g. chlorinated organics, pesticides), heavy metals (e.g. As, Cd, Cr, Pb, Hg, Cu, Ni) and other inorganic compounds (e.g. Ca, K, Na, NH_4, CO_3, SO_4, Cl). Where a landfill site has a leachate collection system, emissions to soil and water are reduced, and treated leachate is discharged to surface water. In addition, vermin can be present at landfill sites and can potentially spread diseases to humans.

11.2 Level of protection

The Danish waste management has resulted in a waste management system with virtually no direct human exposure to waste except in the working environment. The level of protection is considered high, but there are however possibilities for indirect exposure to emissions from waste management such as air pollution from waste incineration or groundwater contamination from landfill leachates.

Human health aspects are generally included in waste legislation, though often not mentioned directly. Reuse and recycling of waste has a high priority in the Danish waste management system. Reuse and recycling of waste back into products used in society allows possible harmful substances to be recycled as well. Therefore, the regulatory framework promotes and regulates the reuse and recycling intent to handle the possible negative effects on environment and health as well. This secures that possible harmful effects and trace components are regulated.

Hygienic aspects in waste management have been in focus since late in the 19th century. These aspects are now rather implicit in Danish legislation. Human health aspects are mentioned directly in provisions regarding hazardous waste. Hazardous waste is characterised as waste which demonstrates one or more of the following properties: health hazard or infectious or fire hazard or harmful to the environment.

Qualitative and quantitative criteria are included in the Statutory Order on Waste. In appendix 3 and 4 of the order are described respectively properties of waste which render them hazardous and percentage limitations (of total content of a category of waste).

A vital health protective measure in the Danish waste management system is the separation, see section below, and classification of waste.

Classification of hazardous waste according to European Waste Catalogue is the duty of the enterprises producing the waste.

11.3 Regulatory framework

11.3.1 Objectives and principles

The objectives of legislation on waste are to minimise the potential environmental impacts and the risks to human health, prevent waste generation, encourage materials and energy recovery, and minimise waste disposal. The legal framework for waste management in Denmark is given in the Environmental Protection Act (Part 6).

The main elements in the Danish waste management strategy are included in the waste hierarchy, in which waste prevention has the highest priority, followed by recycling and reuse, recovery of raw materials and/or the production of energy (including incineration with energy recovery), and finally disposal to landfill.

Source separation
The separation of waste at the source is an important part of the Danish waste management system. Separating waste into different fractions, where this is economically viable and environmentally beneficial, allows a better resource recovery and reduces the potential impact on human health from environmental factors, thereby improving the quality of the waste management. For example, PVC polymer contains a number of additives, the most hazardous of which are stabilisers, in particular those containing heavy metals such as lead and cadmium, and plasticisers, mainly phthalates. When incinerated, PVC increases the quantity of flue gas cleaning residues, and practically all lead and cadmium in PVC end up in these residues, increasing the concentration of heavy metals. PVC also contributes to HCl emissions to air and possibly to the formation of dioxins. The separate collection and recycling or landfilling of PVC would reduce the risk of exposure to environmental factors resulting from incinerating PVC waste together with combustible municipal solid waste.

EU and national legislation
The Danish legislation on waste is characterised by a close interaction between EU regulations and national regulations. The EU regulations outline the overall framework and principles. The actual organisation and implementation of the EU Directives in the national legislation are tasks for the Danish government. The Danish waste model works by a combination of traditional regulations (acts, orders and government circulars), a number of economic instruments such as charges, taxes and subsidies, as well as agreements.

11.3.2 Legislation on waste management

General requirements
The Directive on waste (75/442/EEC), revised and amended in 1991 (91/156/EEC), provides a framework for the environmentally sound management of waste. The Directive covers all waste that is not regulated by separate provisions.

The Directive describes the key elements of a waste management strategy, namely the waste hierarchy, and stipulates that waste must be managed without endangering human health and the environment. The abandonment, dumping or uncontrolled disposal of waste is prohibited, and all waste treatment and disposal facilities must obtain a permit, and be subject to periodic inspections.

The framework Directive on waste has been implemented in Denmark in the Danish Environmental Protection Act and the Statutory Order on Waste.

Hazardous waste
Hazardous waste covers many different categories of waste. The Directive on hazardous waste (91/689/EEC) covers all waste as defined in Annexes I, II and III of the Directive and the list of hazardous wastes in the European Waste Catalogue[97]. Waste is categorised as hazardous if it contains certain hazardous substances, and/or displays the properties that render it hazardous.

The Directive on hazardous waste is supplemented by a number of individual directives regulating specific hazardous waste streams. Basic principles contained in the framework directive on waste and the Directive on hazardous waste on e.g. permits for storing, treating or disposing of hazardous waste also apply to the individual directives for the hazardous waste fractions.

The proportion of all hazardous waste in Denmark was about 2.3 % of the total amount of waste generated in 1998. The implementation of the Directive on Hazardous Waste in the Danish legislation is ensured through provisions in the Statutory Order on Waste. Specific hazardous waste fractions covered by separate directives are also regulated through e.g. statutory orders. Additional waste fractions (for which no directives currently exist) are also regulated in Denmark.

The criteria for waste being hazardous are primarily based on health aspects: Toxic, harmful corrosive, local irritant, allergenic, carcinogenic, mutagenic, teratogenic, harmful to fertility and infectious. But also ecotoxic, flammable and explosive properties are criteria for waste being hazardous.

According to the Statutory Order on Waste the municipalities are obliged to set up collection schemes for hazardous waste generated in industries and households. Most other types of waste, the municipality has to assign to specific treatment facilities. These very strict provisions for hazardous waste, compared to other waste categories, are based on considerations on health aspects and environmental protection aspects.

Transport of hazardous waste
Transboundary movements of hazardous waste follow specific procedures based on prior notification, authorisation and financial guarantees.

The Basel Convention of 1989 on the transboundary movement of hazardous waste and their disposal prohibited the export of hazardous waste from OECD countries to non-OECD countries. One of the main purposes of the Convention is to minimise the movement of hazardous waste. The Convention also defines a number of procedures to be followed such as requirements for notification and authorisation of movements.

[97] Council Decision (94/904/EEC) of 22 December 1994 established a list of hazardous waste pursuant to Article 1 (4) of Directive no. 91/689/EEC.

Together with the other EU Member States, Denmark has implemented the Basel Convention in the Regulation (no. 259/93) on shipments of waste, regulating transboundary movements of waste, including hazardous waste but also non-hazardous waste. The Regulation distinguishes between waste destined for disposal and waste destined for recovery. Since the 1 January 1998, the movement of hazardous waste destined for final disposal from OECD countries to non-OECD countries has been prohibited. The Regulation is supplemented in Danish legislation by a Statutory Order on import and export of waste (no. 971 of 19 November 1996).

The Regulation presents a number of objections to transboundary shipments of waste for disposal. A ban must be justified by the fact that the waste could be disposed of closer to its origin (proximity principle), or that the waste should be recovered (priority for recovery), or that the Community as a whole should become self-sufficient in waste disposal so that the waste problem is not solved by exportation of waste (principle of self-sufficiency).

The movement of waste within a country is also regulated. In Denmark, the Statutory Order on Waste stipulates that private companies transporting waste produced in a municipality must be registered with the local council. When transporting hazardous waste, companies must keep a record of the amount and type of hazardous waste, the waste producer and place of delivery.

Special requirements for specific waste fractions
Requirements for some of the most important hazardous and non-hazardous waste fractions are described in Appendices 7 and 8.

Residual waste from incineration plants
Residual solid waste from incineration plants includes bottom ash (or slag) and flue gas cleaning residues. In Denmark, the majority of bottom ash is recycled in building and construction works; in 1998 more than 80% was recycled and the rest was landfilled. The limit values for heavy metal content in bottom ash have recently been adjusted to increase surface water and groundwater protection, and the minimum distance to the nearest water supplies has been increased to 30 m (Statutory Order on the use of residual waste and soil in building and construction works, no. 655 of 27 June 2000). The consequences, especially in the short term, may be that less bottom ash will meet the criteria and will be landfilled as opposed to be recycled. Direct contact with bottom ash used for e.g. roads, paths and around underground pipes and cables must be prevented by using a layer of soil meeting more stringent quality criteria. In addition, indoor air quality must not be affected where bottom ash is used to build foundations and floors.

Flue gas cleaning residues are classified as hazardous waste due to high concentrations of salts and heavy metals. Initiatives have been launched to establish three landfills receiving all stabilised flue gas cleaning residues generated in Denmark. Once these landfills are in operation, export of flue gas cleaning products will no longer be permitted. Flue gas cleaning residues are currently in temporary storage in Denmark, but since the beginning of 2000 all residues have been exported for landfilling in Norway and Germany.

Residual waste from power plants
Energy generation at Danish power plants is currently based on coal, oil, natural gas, or biofuels. Residues from power plants are not included in the Statutory Order on waste and are not the responsibility of the municipalities.

Hardly any residues are generated at oil and natural gas-fired power plants. Residues (bioash) are produced from the combustion of biofuels and are expected to increase, with the planned increase in the use of biofuels to generate energy over the next 30 years. The recycling of bioash to agricultural land is regulated by the Statuary Order (no. 49 of 20 January 2000).

Residues from coal-fired power plants are slag, fly ash, gypsum, desulphurisation product and sulphuric acid. In 1998, 86% of residues was recycled, although slag and fly ash in particular contain a number of heavy metals that may limit the possibilities for recycling. Just as for residual waste from incineration plants, the limit values for heavy metal content have recently been adjusted.

Residual waste from biological treatment
Organic waste accounts for approximately 40-45 % of domestic waste. In 1997, around 70,000 tonnes of domestic waste were treated biologically, corresponding to 4 % of domestic waste. The majority of organic waste from industry, which is just below 8.5 million tonnes per year, is treated biologically or used directly in agriculture as fertilizer.

Residues from the biological treatment of organic waste are subject to the same requirements as sewage sludge from municipal wastewater treatment plants (refer to Chapter 12 on wastewater). The Statutory Order on the application of waste products for agricultural purposes lays down limit values for a number of heavy metals (e.g. Cd) and cut-off values for organic chemical pollutants (NPE, DEHP, LAS and certain PAHs). In general, the requirements relating to the content of heavy metals and organic substances are not expected to restrict the recycling of biological residues. However, source separated organic household waste may have problematic contents of man-made substances, especially DEHP, if the source separation is not thorough enough. The Statutory Order also places restrictions on the application of residues from biological treatment based on hygienic considerations.

Special requirements for waste facilities

Incineration plants
The Icineration Directive[98] aims to prevent or reduce possible negative effects on the environment from emissions to air, soil, surface water and groundwater, as well as any resulting risk to human health. This aim is to be meet by requiring stringent operational and emission limit values for incineration (and co-incineration) plants. The Directive will cover all waste and introduces far stricter provisions than those found in the existing municipal waste incineration Directives (89/369/ EEC and 89/429/EEC) and in the existing hazardous waste incineration Directive (94/67/EEC), which would be repealed.

The proposed Directive introduces more stringent limit values that will lead to significant reductions in emissions to air of several key pollutants of concern for human health. Considerable reductions at EU level will be achieved for acid gases such as NOx, SO_2 and HCl, as well as for heavy metals, particularly cadmium and mercury. Incineration plants have been identified as a major source of atmospheric emissions of dioxins and furans, and an emission limit value has also been introduced for these toxic organic compounds. There is also a more stringent limit value for total dust, although the finer particulates

[98] Council reached a Common Position adopted on 25 Nov. 1999 (2000/C 76/EC)

(<10μg in diameter) are most harmful to human health. Implementing the draft Directive into Danish legislation will mean that several existing plants will either have to shut down or install supplementary flue gas cleaning equipment, particularly to comply with the limit values for HCl, SO2, dioxins, for which no previous emission limit exists, and Hg.

The draft Directive sets emission limit values from wastewater for the first time, particularly aimed at heavy metals, to reduce the pollution impact of incineration on marine and fresh water ecosystems. The existing Danish limit values for wastewater are generally more stringent than the proposed EU limits.

Finally, the draft Directive stipulates that the amount and toxicity of residual waste from incineration plants must be minimised, and recycled where appropriate, or disposed of under certain conditions (see above section on "Special requirements for specific waste streams").

Landfills

The aim of the landfill Directive (1999/31/EEC) is to ensure minimum requirements for landfill disposal in the EU, in order to prevent or reduce possible negative effects on the environment, from emissions to air, soil, surface water and groundwater, as well as any resulting risk to human health, over the entire lifetime of the landfill. This aim is to be meet by requiring stringent operational and technical requirements at landfills for hazardous, non-hazardous and inert waste.

The Directive stipulates general requirements regarding the location, design and monitoring of landfills. For example, the location of a landfill must consider distances from the site to residential, agricultural and recreation areas, and to the presence of groundwater interests, coastal or nature protection. Landfill gas is to be collected from new landfills receiving biodegradable waste, and the gas used to recover energy or at least flared. Landfills must have liners/ membranes and the leachate should be collected and treated in order to minimise the potential risk of soil, groundwater and surface water contamination.

Waste acceptance criteria are also stipulated in the Directive. The landfilling of certain wastes including used tyres and liquid waste is banned, and reduction targets exist for the amount of biodegradable municipal waste going to landfills.

The landfill Directive will be implemented in Danish legislation by July 2001 via amendments to the Environmental Protection Act, and subsequent changes to statutory orders. In Denmark, only public authorities can own new landfill sites. Existing landfills must draw up a conditioning plan, stating the measures needed to upgrade the landfill to comply with the requirements for new landfills by July 2009 or alternatively close the landfill site as soon as possible. The landfilling of combustible waste has been banned in Denmark since 1997, and the reduction targets for landfilling of biodegradable munici-pal waste will not have any influence in Denmark, as almost all biodegradable municipal waste is treated biologically or incinerated.

Waste recycling facilities
In 1998, 62 % of the total amount of waste generated in Denmark was recycled[99]. Waste is recycled and treated at a number of Danish recycling facilities, e.g. composting and biogasification plants, steel mills, crushing facilities for construction and demolition waste, some treatment facilities for hazardous waste (where oil and chemicals are recovered), bottle cleaning facilities, glass factories, paper factories and plastic factories. The recycling facilities are owned both privately and publicly.

Danish recycling facilities are required to apply for environmental approvals (According to Chapter 5 in the Environmental Protection Act and Statutory Order on Approval of Listed Activities no. 807, of October 25, 1999). Environmental approvals or permits are issued by the municipal or county authorities, depending on the category of polluting activity and the ownership of the specific waste facility. Environmental approvals are granted provided that specific conditions or requirements are fulfilled, such as that emission limit values are met, and the best available technology is used to prevent and reduce pollution.

11.4 Instruments

11.4.1 Regulatory instruments

Action plans
In Waste 21 (The Danish Government's Waste Management Plan 1998-2004) health aspects are mentioned directly in sections regarding health care risk waste, transport of hazardous waste, PCB/PCT-waste and residual waste from power plants. The health aspect though is implicitly included in a number of other sections as well, e.g. electrical and electronic equipment, refrigeration equipment, CFC.

As waste management has paid attention to health aspects since late in the 19 century, human health is regarded, but often only implicitly. "Environmental protection" is often used synonymous with protection of both environment and human health.

Voluntary agreements
During the 1990s, the Danish Ministry of Environment and Energy entered into a number of agreements with relevant organisations to ensure the separate collection of certain special wastes. The objective was to establish systems that would encourage individual households to participate in recycling. Voluntary agreements specify a goal for recycling of the given waste stream. If the goal is reached, the system will stabilise; if not, political initiatives are often taken to reach the goal.

NiCd batteries
The oldest voluntary agreement regarding waste is the 1991 agreement on nickel-cadmium (NiCd) batteries[100]. The goal was to collect 75% of all NiCd batteries. The collection percentage was only 35% after some years and it was

---

[99] 10 % of the waste was exported, and the waste imported was a little over 4 % of the waste amount generated in Denmark (in 1998).
[100] Voluntary agreement on collection of rechargeable batteries containing cadmium, Sept. 1991.

decided to denounce the agreement. Thus in an attempt to increase the collection percentage, the Minister for Environment and Energy imposed a green tax on NiCd batteries of DKK 6 per cell and DKK 36 per package, while at the same time introducing bonus of DKK 150 per kg to the parties collecting spent batteries.

Transport packaging
In 1994, an agreement was made on the recycling of transport packaging materials[101]. The goal is to recycle 80% of all transport packaging materials. It is intended that this should be attained through the participation of trade enterprises in municipal collection schemes, including the Confederation of Danish Industries, the Danish Plastics Federation, and the Packaging Industry.

Tyres
Originally made in 1993, a new agreement with the Danish Motor Trade Association, the Association of Danish Recycling Industries, and municipal associations came into effect in 1995[102]. The goal is to recycle at least 80% of all types of scrap tyres by 2004, thereby reducing the amount of scrap tyres deposited at landfills. A consumer levy of DKK 8 per new tyre is used as a subsidy for enterprises that collect tyres and deliver them to enterprises where the tyres are converted to rubber granulate.

Lead accumulators
A formal agreement has been made for lead accumulators between the minister and the association for collection of lead accumulators (importers and retailers). The goal of the agreement is to achieve a collection percentage of 99,9% for lead accumulators, with a current percentage recovery of 99,9%. Legislative intervention has now taken place, just as for NiCd batteries.

Building materials
An agreement was made in 1996 with the Danish Demolition Association on the selective demolition of building materials, thereby ensuring source separation of waste.

Refrigeration equipment
The collection and safe disposal of CFC-containing refrigeration equipment is ensured by an agreement with the relevant associations involved. The objective is to collect a minimum of 90% of discarded refrigeration equipment by 2004.

11.4.2 Economic instruments

The most important economic instruments used in Denmark with respect to waste management are taxes, especially the waste disposal tax, and deposit-refund systems.

Product Tax
Specific product green taxes exist, for example on NiCd (nickel and cadmium) batteries. The tax aims at reducing the use and increasing the recovery rates of NiCd batteries.

---

[101] Agreement between Ministry of Environment and Energy and Danish Industry regarding reuse of transport packaging, Aug. 1994.
[102] Agreement between Organisations and the Ministry on Environment and Energy regarding return obligations for used tyres, Feb. 1995.

Denmark applies a product tax on packaging; the Act (No. 726 of 7 October 1998) has been in force since 1 January 1999. The environmental aim of the tax is to encourage the use of reusable/refillable packaging and reduce the amount of packaging waste. The tax applies to containers made of among others plastic, glass, metal, cardboard, and composites, as well as paper and plastic carrier bags. The charge affects foodstuffs (such as beverages, oil, vinegar, margarine) but also includes soaps, detergents, lubricants, pesticides. The revenue amounted to MDKK 809 in 1998.

Waste Disposal Tax
In 1990, all non-hazardous waste became subject to a tax. In 2000 and 2001 the tax is 375 DKK per ton for waste landfilled. The charge for waste incineration is 330 DKK per ton in 2001, in 2000 the charge differed: 280 DKK and 330 DKK with and without energy recovery respectively. Waste that is recovered, recycled, reused or composted is exempt from the tax. In 1998, the waste tax raised MDKK 889 (DEPA, 1999a).

The purpose of the tax is to encourage recycling and increase the proportion of waste managed by techniques towards the top of the waste management hierarchy. The waste disposal tax has been a very important instrument and has lead to a significant increase in recycling, as well as a significant decrease in the amount of waste landfilled. Only 15% of the total waste generated was landfilled in 1997. As for possible fraud, no increase in illicit dumping of waste has been reported since the charge was introduced.

Deposit-Refund System
Since 1984 in Denmark, beer and soft drinks may only be sold in containers that can either be refilled or recycled. Statutory Order no. 124 of 27 February 1989 requires that for containers produced in Denmark must be refillable, be a part of a deposit-return system, and approved by DEPA. The deposit for small bottles (<50 cl) is 1.25 DKK, and between 2.5 and 4 DKK for large bottles.

The purpose of these mandatory systems is to limit waste from packaging by encouraging the reuse of beverage containers. The return rates are over 99%; the average number of times a glass bottle is reused is 35-40. The high return rates may also imply that less broken glass is found in public spaces, reducing the risk of injury from broken glass.

User Fees for Waste
The aim of the waste fee is to make the user (e.g. households, enterprises etc.) of the municipal collection service pay for the costs associated with waste management, in accordance with the polluter pays principle. The waste fee covers the costs incurred by the municipality and should correspond to the level of service provided.

Subsidies to promote cleaner technology and waste recovery
Subsidies have been allocated to projects promoting cleaner technology, which aims at minimising the potential environmental and health risks that occur during the entire lifetime of products, including during waste management. In 1998, the budget for projects in the area of cleaner technology was close to 90 MDKK. Subsidies have also funded projects in the area of waste recovery including projects aimed at mitigating impacts related to recovery, recycling and treatment of waste. In 1998, the budget for projects concerning waste recovery projects was about 115 MDKK (DEPA, 1999).

11.5 Actors

The primary actors concerning regulation of waste management are listed in table 11.2. For general descriptions of the mentioned actors please refer to chapter 3.

Table 11.2 Actors, roles and responsibilities concerning waste management

Actors	Roles and responsibilities concerning waste management
The Danish Environmental Protection Agency (DEPA)	DEPA plays the role as conductors of tasks, defined in the Environmental Protection Act as tasks of the Minister of Environment and Energy. DEPA administers in co-operation with the municipalities, the Minister and the Ministry of Environment and Energy the legislation on waste. The Agency prepares statutory orders on waste and specific categories of waste. This work includes definition of criteria for hazardous waste, including waste with an impact on human health. DEPA provides guidance for the work of the local authorities and supports research and development. In the waste legislation, the tasks of DEPA are defined as granting exemptions and receiving reports from waste facilities, waste producers, municipalities. This only illustrates that DEPA is highest authority regarding these questions.
The medical officer on health	The medical officer on health has practically no specific role concerning waste management.
Counties	The county councils shall inform the Municipality as to whether the municipal waste management plan is in accordance with the strategy and assumptions in the county's Regional Plan. According the Planning Act, the county is responsible for making provisions for the location of polluting enterprises, including new landfill sites, incineration plants and other waste treatment facilities.
Municipalities	Municipalities are responsible for waste management, and are obliged to ensure that all waste produced within the municipality is collected and treated appropriately. The Environmental Protection Act and the Statutory Order on Waste stipulate the responsibilities of the municipality, which include: • the preparation every 4 years of a short term (4 year) and a long term (12 year) waste plan for the municipality • the preparation of by-laws detailing the arrangements made in the municipality • ensuring that the waste hierarchy is observed and ensuring that waste is handled in an environmentally safe manner, either via assignment or collection arrangements • enforcing the national and municipal waste management legislation.
Inter-municipal waste associations	The vast majority of Danish municipalities are members of Inter-municipal Waste Associations. Altogether, 34 such waste co-operations have been established in Denmark. The tasks delegated by the municipalities to the inter-municipal associations can vary. Typically, the daily management of waste facilities such as incineration plants, landfill sites, composting facilities, recycling stations, and central sorting facilities for recyclable paper and cardboard is undertaken by the associations. In many cases, waste planning, the preparation of by-laws and collection of waste is included in the tasks of the waste association.
Waste facilities	A number of private companies operate material recycling facilities for certain recyclable waste fractions, e.g. paper, glass.

Actors	Roles and responsibilities concerning waste management
Transportation companies	Typically, the municipality or the inter-municipal waste association collects waste by licitation. It is estimated that private collection companies collect about 80 % of all household waste in Denmark, and about 20 % of household waste is collected by the "municipal bodies". Private waste transportation companies also collect practically all waste from private enterprises, except the mayor part of hazardous waste.
Waste producers	Waste producers are an important factor in the success of waste management. Active participation in waste collection and recycling schemes is required to achieve high recovery rates, as well as to separate hazardous waste from the bulk of the waste stream. In Denmark, the Government's Waste Management Plan 1998-2004 specifically states that waste producers must play a more active role in waste management solutions.

11.6 Evaluation

Danish waste regulation has been very successful in hindering human contact with waste, but still humans may be indirectly exposed to emissions from waste management. The overall health objective of the waste regulation is to avoid any harmful impact on public health, whether it is directly through contact with waste or indirectly through emissions from waste management. From the start of waste management history - more than hundred years ago - protection of public health has been an integrated part of waste regulation to a degree where special objectives concerning public health only seldom are mentioned explicitly.

The principal strategy is to prioritise waste management in the following order (the waste hierarchy):

1. Waste prevention
2. Reuse
3. Recycling
4. Incineration with energy recovery
5. Landfill disposal

The regulation of the waste area in Denmark is generally very detailed, and the degree of recycling is high. However, it is still the aim to increase the degree of recycling and to identify and separate the problematic waste fractions in order to limit the emissions of substances that may have a negative impact on human health and the environment. The instruments used are both a detailed regulation and economic instruments such as taxes and waste fees. Among the regulatory instruments, the regulations on specific waste fractions and on hazardous waste should be noted. The objective is to separate out the most problematic waste fractions, in order to improve the possibilities for recycling of the remaining waste stream. Also, the general principle of waste separation as close to the source as possible is crucial to the possibilities for recycling and reuse.

Even though waste regulation is very detailed not all of the special regulations have yet reached their full effect. Present problems are primarily connected to emissions from waste management, and especially dioxin emissions from waste incineration should be noted (as described in chapter 5).

The challenges to the waste regulation and management of today are:

- To direct the waste streams as high as possible in the waste hierarchy.

- To observe and minimise negative effects on health and environment from waste minimisation and increased recycling (e.g. wastewater sludge, organic waste, incineration slag and PVC).

Waste minimisation and waste prevention are of prime importance in the aim of sustainable development. Focus must be on the source of the waste production and increased producer responsibility. Another trend will be the increased recycling of waste products. Because of the often very complex composition of waste it will be important to gain more knowledge on waste composition and the potential human exposure and health effects especially connected to waste recycling. A special issue, which demands future attention, is the regulation of animal waste from meat-industries/slaughterhouses.

11.7 References

Literature

DEPA (1997) "*Hygienic aspects of treatment and reuse of organic waste*", Environmental Project no. 351, Danish Environmental Protection Agency, Ministry of Environment and Energy, Copenhagen.

DEPA (1999a) "*Economic Instruments in Environmental Protection in Denmark*", Danish Environmental Protection Agency, Ministry of Environment and Energy, Copenhagen.

DEPA (1999b) "*Waste in Denmark*", Danish Environmental Protection Agency, Copenhagen, Denmark.

Waste 21 (1999) The Danish Government's Waste Management Plan 1998-2004, Ministry of Environment and Energy, Copenhagen.

Danish Legislation

Environmental Protection Act, no. 625 of July 15, 1997, and amendments.

Statutory Order no. 619 of June 27, 2000 on Waste.

Statutory Order no. 807 of October 25, 1999 on Approval of Listed Activities.

Statutory Order no. 39 of 20 January 2000 on use of ash from gasification and combustion of biomass and biomass waste for agricultural and related purposes (the "Statutory Order on bioash").

Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes (the "Statutory Order on Sludge").

Statutory Order no. 1044 of December 16, 1999 on certain batteries and accumulators that contain hazardous substances.

Statutory Order no. 91 of 22 February 1996 on Collection of Lead Accumulators and Subsidy to Collection and Disposal for Recycling.

Statutory Order no. 92 of 22 February 1996 on Fees on Lead Accumulators,.

Statutory Order no. 93 of 22 February 1996 on Collection of Hermetically Sealed Nickel-Cadmium Accumulators (Closed Nickel-Cadmium Batteries) and Remuneration for Collection and Disposal for Recycling.

Statutory Order no. 925 of 13 December 1998 on PCB, PCT and substitute substances.

Statutory Order no. 860 of 29 November 1999 on management of waste in the form of motor vehicles and derived waste.

Statutory Order no. 141 of 25 February 2000 on collection of environmental charge and remuneration in relation to scrapping of cars.

Statutory Order no. 655 of 27 June 2000 on the use of residual waste and soil in building and construction works.

Statutory Order no. 1067 of 12 December 1998 on management of waste from electric and electronic products.

EU Legislation

Framework Directive on Waste 75/442/EEC. Amended by Directive 91/156/EEC of 18 March 1991.

Directive 91/689/EEC of 12 December 1991 on hazardous waste. Amended by Directive 94/31/EC of 27 July 1994.

Directive 96/59/EEC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCBs/PCTs).

Directive 91/157/EEC of 18 March 1991 on batteries and accumulators containing certain dangerous substances. Amended by Directive 93/86/EEC of 4 October 1993; Directive 98/101/EC of 22 December 1998.

Directive 75/439/EEC of 16 June 1975 on the disposal of waste oil. Amended by Directive 87/101/EEC of 22 December 1986; Directive 91/692/EEC of 23 December 1991.

Council Regulation no. 259/93 on the supervision and control of shipments of waste within, into and out of the European Community, as amended by Council Regulation No. 120/97 of 20 January 1997.

Council Directive 94/62/EC of 15 December 1994 on packaging and packaging waste.

Proposal for a Directive of the European Parliament and of the Council on Waste Electrical and Electronic Equipment and on the restriction of the use of certain hazardous substances in electrical and electronic equipment COM(2000) 347.

Healthcare risk waste, Guideline no. 4 of 1998.

Circular on Municipal Regulation of Sorting of Construction and Demolition Waste for the Purpose of Recycling, no. 94 of 21 June 1995.

Circular on municipal by-laws on disposal of CFC-containing refrigeration equipment, no. 132 of June 13, 1996.

Statutory Order no. 971 of 19 November 1996 on the import and export of waste.

Statutory Order no. 298 of 30 April 1997 on certain requirements for packaging.

Act on charges on certain packaging and certain paper or plastic carrier bags etc., No. 726 of 7 October 1998

Statutory Order no. 124 of 27 February 1989 on packaging for beer and soft drinks, with subsequent amendments (Statutory Order no. 583 of 24/06/1996; Statutory Order no. 540 of 09/07/1991; Statutory Order no. 300 of 30/04/1997).

Statutory Order no. 1067 of 22 December 1998 on management of waste from electrical and electronic products.

12 Wastewater

12.1 Human Exposure to Environmental Factors

12.1.1 Environmental factors

In a historic perspective, the main objective of the Danish wastewater management has been hindering human contact with wastewater and hereby to avoid transference of diseases. Secondly, and especially since the 1970s there has been focus on wastewater impact on nature. Eutrification of lakes, pollution of streams and coastal waters causing fish death has been a main concern related to discharge of wastewater for the last 20 years.

Generally, the strategy has succeeded in hindering human contact with wastewater. However, some examples of human exposure exist.

The health risk from wastewater is obvious when wastewater from a damaged sewer pipe in very rare cases reaches a drinking water borehole or infiltrates the water supply system causing intestinal diseases to the consumers (examples from smaller Danish towns are Klarup 1996 and Uggerløse 1991-92). But uncertainties remain concerning the nature of the health risk from bathing in recipients contaminated by wastewater and the long-term effect from the low-level chronic exposures to heavy metals accumulated in agricultural products. Wastewater management in Denmark aims at reducing these health risks.

Reuse of raw or treated wastewater is extremely rare. However, the DEPA has investigated the potential health risk from handling raw wastewater including the separation of faeces and urine as part of its programme for Ecological Town Planning and Wastewater Treatment.

Health concern related to chemical contaminants in wastewater focuses on heavy metals and man-made chemical substances. Especially, the risk of accumulation in fish in receiving waters or the risk of transference to agricultural crops when sludge is applied as a fertiliser in agriculture.

To summarize, the potential ways of exposure to environmental factors from handling and disposal of wastewater can be divided into three categories:

1. Direct exposure to substances in wastewater (working environment) and in receiving waters (bathing waters)

2. Indirect exposure to substances leaching to groundwater (drinking water).

3. Indirect exposure to substances in sludge deposited on or adsorbed on roots of crops (foods, not covered under this project).

The following table 12.1 gives an overview of environmental factors related to human health.

Table 12.1 Summary of the origin, characteristics and potential health impacts of some critical wastewater pollutants.

Environmental factor	Origin and characteristics	Potential health Impact
Anthropogenic organic substances. Examples: Organic solvents Plastisizers (e.g. DEHP) Detergents (e.g. LAS,NPE) Complexing agents (EDTA, NTA) Polyaromatic hydrocarbons (PAH) Phenols	Domestic and industrial discharge, run-off from road surfaces.	Carcinogenic effects Reproductive toxicity Organ toxicity Acute toxicity
Heavy metals Examples: Pb, Cd, Hg, Cr, Ni, etc.	Discharge from industries, medical institutions, road surfaces and roofs	Ni allergy Neurotoxic effects Suspected carcinogens.
Bacteria Examples: Coli, Enterococci, Salmonella, Campylobacter **Virus** Examples: Hepatitis A virus, Enterovirus, Adeno virus, Calici virus, Coxackie virus, Rota virus and Norwalk agent **Protozoans (examples)** Cryptosporidium parvum, Giardia intestinalis (duonenalis), Ascaris	Sewage effluents and wastewater from the meat industries discharged to water recipient (potentially affecting bathing water)	Gastro-intestinal symptoms Diarrhoea, Vomiting Fever, abdominal pain Diarrhoea Abdominal pain

Abbreviations:

DEPH: bis (2-Ethylhexyl)phthalate
LAS: linear alkylbenzene sulphonate
NPE: nonylphenolethoxylate
EDTA: ethylenediaminitetraacetic acid
NTA: nitrilotriacetic acid
PAH: polycyclic aromatic hydrocarbon

12.1.2 Wastewater management

Figure 12.1 shows wastewater management from the wastewater producer to final disposal. The wastewater producers are households, commerce and institutions, industries and urban surfaces. The run-off from rural surfaces, including agricultural areas is not considered part of the term wastewater.

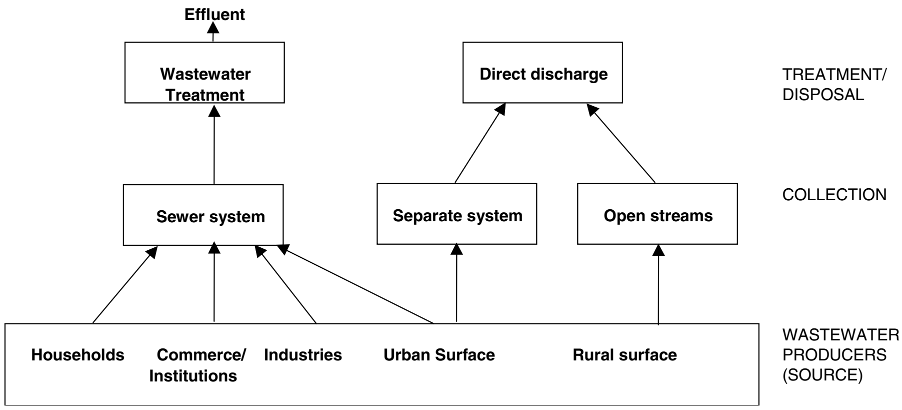


Figure 12.1 Wastewater management

Wastewater is transported in closed pipe systems except for a very few cases where holding tanks are emptied by sludge trucks. In the sewer system, minimal energy is used for pumping wastewater depending on the topography. The sewer system can pollute the surrounding soil and later on groundwater through leakage from open joints or broken pipes.

Rainwater from roofs, squares and streets are in some cases transported in a combined system together with wastewater to a wastewater treatment plant. After a heavy rainfall, overflow structures in the sewer system may discharge diluted wastewater untreated to the recipient. This can cause a dramatic decrease in the microbiological quality of the receiving water rendering the water unsafe for bathing. In this connection it is a problem that the bathing water control is based on the monitoring results from the previous year, meaning there is no reaction to the actual overflow situation (for more details please refer to chapter 8 on bathing water).

The primary wastewater impact on bathing waters is by overflow of untreated wastewater during heavy rain, but also of importance is run-off from rural areas and from scattered settlements in the countryside not being connected to a wastewater treatment plant. Today approximately 130,000 private residences and 13,000 summerhouses discharge wastewater directly from a settling tank, which with respect to micro-organisms is virtually untreated. The wastewater is discharged to drains, ditches, watercourses, lakes and to the sea giving un-hygienic conditions, especially in recipients with low water exchange.

In May 1997, the Danish Parliament agreed upon an action plan for improved wastewater treatment involving approximately 64,000 scattered settlements in the countryside. The actions will include connection to public wastewater treatment, local sand infiltration plants or small wastewater treatment plants. This action plan will contribute to the improvement of the general water quality in fjords, lakes and coastal waters and thereby also contribute to improvements of the bathing water quality.

The action plan raises some issues regarding the groundwater protection. Approximately 30,000 local sand infiltration plants are expected to be installed at individual houses, which may imply leaching of substances to the groundwater. Especially household detergents are in focus.

Another potential source of wastewater infiltration in sewer pipes, which are never 100 percent tight. However, there are in Denmark few documented cases of drinking water contamination caused by infiltration of wastewater. The reason is probably, that leaks are sealed by the suspended matter in the wastewater.

Urban surface run-off, which is discharged separately to the recipient, causes contamination with nitrogen compounds (e.g. from rain), heavy metals (e.g. from traffic, industrial storage sites and roofs) and oil related products (e.g. traffic, gas filling stations and storage sites). The extent of contamination of surface waters with microbiological agents from direct surface run-off is unknown.

12.1.3 Wastewater treatment

Repeating incidences in the mid-1980s of oxygen depletion in Danish fjords and coastal water led in 1987 to the Danish Action plan for the Water Environment. The action plan set minimum national standards for discharge of effluent concerning organic compounds and the nutrients nitrogen and phosphorus. The result was a reduction in wastewater impact on the water environment in Denmark (improved wastewater cleaning technology, sharpened discharge requirements, dimensioning of retention basins to minimise overflow, etc.).

For wastewater treatment plants, tertiary treatment was demanded for all plants bigger than 5,000 person equivalents (PE). The extension of the treatment plants to tertiary treatment was finalised in 1995. Today, nearly all wastewater (99%) connected to sewers in Denmark is being treated in a wastewater treatment plant. Out of these, approx. 94% is applying tertiary treatment (mechanical, biological and chemical). The treatment plants are in general designed to reduce the organic content, and the content of total nitrogen and phosphorus down to very strict demands. Occasionally, limits are set for the discharge of ammonia or nitrates.

Industrial discharges are mainly connected to the public tertiary wastewater treatment plants, and only a minor number of industries have a direct discharge to the aquatic environment of wastewater treated on their own.

The improvements of the wastewater treatment plants have led to a substantial decrease in the discharge of pathogenic micro-organisms. When supplementing secondary (biological) treatment with tertiary (chemical) treatment, the discharge of E. Coli, which is an indicator of faecal pollution, is reduced by a factor 10. However, the content of pathogens may still pose a risk to people bathing in waters affected by wastewater (please refer to chapter 8 on bathing water for more information). Effluent from Danish wastewater treatment plants typically have an E.Coli concentration of 10.000-100.000 cfu / 100 ml.

It is therefore continuously discussed whether disinfection should be added to the treatment (e.g. by UV radiation or ozone treatment). If so decided, the monitoring programmes for outlets and bathing waters will also have to be changed, because disinfection will especially decrease the micro-organisms, which today are used as indicators (E. coli etc.). Indicators have to be found for the more resistant micro-organisms.

As shown in figure 12.2, a wastewater treatment plant consumes resources and produces emissions and waste, some of which have a human health impact. Wastewater treatment plants can have their own sludge incineration facility causing air emission and the production of heavy metal loaded ash. The production of biogas from digesting sludge replaces fossil energy sources. Material in the wastewater retained on screens and in grit chambers are deposited on landfills or taken to an external incineration plant and treated together with solid waste.

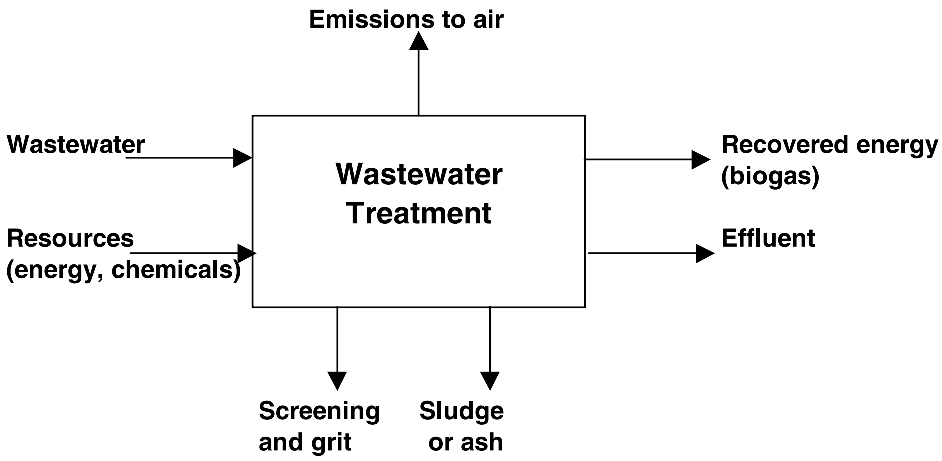


Figure 12.2 Consumption and production in a wastewater treatment plant

Effluent is discharged to streams, lakes or the sea containing pathogens and heavy metals with potential human health risks if the waters are used for bathing. Sludge is after treatment used as fertiliser on agricultural land, taken to a composting plant, incinerated or deposited on a landfill.

The direct exposure to wastewater can take place when working in the sewer system or at the wastewater treatment plant. The health risk arises both from direct contact with the wastewater or by inhaling aerosols carrying pathogens or by toxic gases like hydrogen sulphides (H_2S). These risk factors primarily belong to health risks in the working environment, but neighbours may also be affected through airborne spreading of aerosols or gases.

12.2 Level of protection

All wastewater produced in Denmark is to be collected and treated. Even single houses in the so-called "open land" are requested to have their wastewater treated (although no time limit is given in the present regulation). Both the general effluent limit values and the requested national "coverage" of treatment are stricter in Denmark compared to the present EU directives.

Although the primary objective of legislation and regulation is protection of the environment, a high level of protection of public health is achieved through:

- virtually no direct access to wastewater
- strict discharge limit values, which are set for water environments that are more sensitive than humans.

Table 12.2. Examples of Quality Standards for Fresh water and Marine water

	Fresh water (µg/l)	Marine water (µg/l)
Cadmium	5.0	2.5
Chromium	1.0	10.0
Copper	2.9	12.0
Formaldehyde	95,000	95,000
Lead	5.6	3.2
Mercury	1.0	0.3
Nickel	8.3	160.0
PAH (each compound)	0.001	0.001
Phenol	1,000	1,000
Zinc	86.0	110.0

However, problems with bathing waters occur in some cases and uncertainty remains concerning the nature of the health risk from bathing in wastewater contaminated recipients, especially with respect to pathogens.

12.3 Regulatory framework

12.3.1 Objectives and principles

The primary objectives of the legislation and regulation of wastewater in Denmark with respect to public health are:

- To prevent illness in the general population from direct contact with wastewater (discharges to sea, water courses, lakes or soil)

- and from indirect contact with wastewater (through drinking water).

- Application of sewage sludge to agricultural land must be performed in such a way that pathogens are not transferred to humans, neither directly (via birds and animals) nor indirectly (via crops).

- Public health shall not be unacceptably impacted by contamination effects derived from wastewater influence e.g. eutrofication of surface waters or accumulation through food-chains of heavy metals and man-made chemicals in animals and humans.

In the 1970s, all Danish municipalities prepared their first wastewater master plan, which included implementation plans for the collection and treatment of all point sources. During the 1980s, the Danish counties prepared water quality plans for surface water recipients defining the quality requirements of the receiving water.

12.3.2 Legislation

The overall regulation of wastewater discharge in Denmark is regulated through the Environmental Protection Act (no. 698 of 22 Sept. 1998) and the Planning Act (no. 518 of 11 June 2000).

Planning Act
The Planning Act – and orders and guidelines prepared under the act – regulates physical planning in Denmark (see chapter 3 for more detailed information).

According to the Planning Act each county shall prepare a plan for the county (regional plan) in which guidelines for the use and state of different areas within the county are stated. With regards to waters, the quality and use of streams, lakes, and sea shall be stated. However, the requirements for discharges to these waters will normally follow the general national requirements as stated in the statutory orders of the Environmental Protection Act.

The county can set out the objective for receiving water to comply with bathing water quality or to comply with the quality standards required to use the receiving waters as a drinking water source, etc.

Environmental Protection Act
The Environmental Protection Act, chapter 4, regulates protection of surface water by outlining principles for discharge of wastewater.

Chapter 3 regulates the protection of soil and groundwater, including utilisation of sludge from wastewater treatment plants as fertiliser in agriculture.

Chapter 5 of the Environmental Protection Act regulates the polluting industries and institutions/commercial areas. It sets out principles for how a county and/or a municipality monitors and regulates non-residential discharges.

The three key statutory orders concerning wastewater are:

- Statutory Order on discharge permits according to chapter 3 and 4 of the Environmental Protection Act (no. 501, 21 June 1999).

- Statutory Order on quality criteria for wetlands and criteria for discharge of certain dangerous substances to streams, lakes or the sea (no. 921, 8 October 1996).

- Statutory Order on use of waste products for agricultural and related purposes (no. 49 of 20 January 2000) also called the "Statutory Order on Sludge".

These statutory orders set out limits to the content of chemical substances, which are identified as being toxic, persistent or accumulating in nature. Additionally, the statutory order on sludge states hygienic requirements on the use of sludge.

According to the above acts, the municipality and the county administer the statutory orders by intervention at potential sources. In order to assist the interventions at polluting industries, the Ministry of Environment and Energy has issued a number of statutory orders aiming at special types of industries.

Utilisation of sludge as fertiliser

For many years it has been attempted to recycle sludge from wastewater treatment plants on farmland as a fertiliser. However, difficulties in reaching the required criteria for the sludge and boycotts by farmers have made it necessary to dispose part of the sludge as landfill or incinerated. Incineration, composting or disposal as landfill is covered by the legislation on waste.

Sludge from wastewater treatment plants can be used as fertiliser and soil improver in agriculture, horticulture and forestry providing regulatory conditions are fulfilled. Such uses of waste products are regulated by the Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes (the "Statutory Order on Sludge"). Herein maximum levels of 7 heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn) and 4 organic chemical contaminants (DEHP, LAS, NPE, PAH) as well as maximum application amounts are stipulated. Furthermore, the statutory order contains soil quality criteria for farmland, that must not be exceeded if the utilisation of sludge on the farmland shall be permitted (these soil quality criteria are referred in chapter 6).

If farmland soil and sludge fulfil the above criteria, certain hygienic based limitations are imposed depending on the treatment of the sludge. If the sludge has undergone a process of hygienisation and therefore contains less than 100 faecal streptococci/g and no salmonella, no restrictions are imposed on the use. If the sludge has been through a stabilisation or composting process, the sludge may not be placed on farmland with directly consumable products. Further requirements for the use of composted or stabilised sludge include e.g. ploughing the sludge into ground within a given number of hours, closing the forest for public entrance etc. If the sludge has not received any treatment it can not be used as fertiliser on farmland.

12.4 Instruments

12.4.1 Regulatory instruments

Norms

To prevent the risk of leakage of wastewater from sewers, the installation of sewers is required to comply with certain norms: Danish Standard (DS).

Wastewater master plans

In accordance with the Environmental Protection Act, Art. 32 the municipality shall prepare a wastewater master plan for the municipality. The wastewater master plan shall be in accordance with the county regional plan. The master plan shall contain a complete description of wastewater handling including information on the entire sewer network and treatment facilities as well as a schedule for repair and extension.

Today, the contamination of bathing water with microbiological agents through wastewater mainly originates in stormwater overflows on combined sewer systems. On the regional plan, a county may set out the maximum number of discharges per year allowed for a specific receiving water. The municipality will in its wastewater master plan describe how this is achieved, either by building larger retention basins, by separation of wastewater from rainwater, or by direct infiltration of roof rainwater through fascines.

Even though wastewater planning seeks to avoid contamination of bathing waters through improvement of treatment facilities, dimensioning of retention basins and location of discharge points, problems prevail in some areas.

Discharge permits

In order to discharge wastewater (treated or not treated) it is required to obtain a discharge permit from the proper environmental authority. Based on the Environmental Protection Act, the regulation of discharge permits is stated in the statutory orders no. 501 of 21 June 1999 and no. 921 of 8 October 1996. In general, the county gives permission to discharge wastewater to streams, lakes or the sea and the municipality gives permission to connect wastewater to public sewerage systems.

The statutory order no. 921 of 8 October 1996 on quality criteria for wetlands etc. is aiming at minimising the contents of substances dangerous to nature or health in discharges to the recipients. Directly relevant for health is the accumulation of heavy metals and other toxic substances in fish, which are caught and consumed in a non-commercial activity. The requirements in form of effluent criteria in the statutory order no. 501 of 21 June 1999 are mainly focusing on treatment of organic matter and nutrients, which are of environmental concern, but in this context not relevant to human health.

The requirements for more extensive treatment of nutrients, however, have an effect on the cleaning efficiency of the wastewater treatment plant for the pathogenic micro-organisms. Treatment of wastewater involving removal of only organic compounds (mechanical, biological treatment) will for instance remove approximately 90% of the E. Coli, whereas adding removal of nutrients (including nitrification, denitrication, chemical removal of pho-sphorous) will remove approximately 99 % of the faecal bacteria. However, depending of the start concentration, the concentration may still be too high for discharge into bathing waters.

The municipal wastewater treatment plant will have to apply for a discharge permit at the county, which will require compliance with the effluent criteria as stated in the statutory order 501 or better. The general effluent criteria for public wastewater treatment plants depend on load of the treatment plant calculated as the number of personal equivalents (PE).

In special cases, an industry can be allowed to discharge directly to the recipient, and the statutory order no. 501 1999 and statutory order no. 921 also states the general requirements for this kind of discharge.

Connection permits

All buildings situated in a public sewer catchment area are in general required to connect to the public sewer unless they are located in an area where the municipality accepts local discharge (typical rural areas). Local discharge will - according to the statutory order no. 501 of 21 June 1999 - also be subject to requirements of treatment as described in statutory order no. 500 of 21 June 1999 on mini-treatment plants (5-30 PE).

In Denmark almost all industries and residential areas are localised within a public sewer catchment area. Most wastewater is therefore connected to a public sewer and treated in municipal wastewater treatment plants prior to discharge to the recipient. When connecting to the public sewer, the municipality will prepare a connection permit, which in case of polluting industries, may involve requirements to the quality and amount of wastewater.

When interpreting the statutory order no. 501, 1999, the local authorities can use the guideline to the order: Guideline no. 5, 1999 and a special guideline for the connection of industrial wastewater to the public sewer: Guideline no. 6, 1994.

The municipality shall, when stating the requirements in a connection permit, ensure the safe transport of the sewage to the wastewater treatment plant, taking the health of sewer workers into consideration as well as the risk of corrosion of the sewer pipes. Furthermore, it must be ensured that the function of the wastewater treatment plant is not endangered and that the quality of the sludge is not reduced.

Depending on the quality of the wastewater from an industry, the municipality may require pre-treatment at the industry in the connection permit.

Discharge of hazardous substances

The statutory order no. 921 for Wastewater Discharge to Recipients, Annex 1 lists hazardous substances, which are to be regulated in wastewater discharge. DEPA has in its Environmental Project no. 250, 1994 described how this list should be understood. In its work with a discharge permit for an industry, the county must consider two issues: (1) best available technology and (2) quality criteria for the receiving water. Two strategies are therefore combined (the combined approach) and whichever of the two leads to the strictest effluent criteria will be applied. This means that if discharge based on the best available technology results in quality criteria, which are lower than the one defined in the counties regional plan, the discharge should be based on the best available technology.

A county is guided in its work with discharge permits through a number of publications by DEPA (so-called Environmental Projects) like no. 260, 1994, Environmental toxicity of industrial wastewater and no. 188, 1992 Ecotoxicological evaluation of industrial wastewater.

The monitoring of discharge permits will be adapted to individual local conditions. The discharge permits are therefore set depending on the acute or chronic effect or potential bioaccumulation of relevant substances.

Acute effect is considered by setting standards to maximum concentration, whereas chronic effects are considered by setting average concentration over a certain period in combination with maximum volume of water discharged. By combination of the latter indirect standards are set for the amount of substance that can be discharged over a given period.

Monitoring

The discharges from industries and commercial activities are monitored according to a programme agreed between DEPA and the Danish Society of Municipalities, implying that the municipalities have to inspect industries at a certain frequency. Major industries are requested to self-monitor and report their discharge regularly and the municipalities will receive the results. The analyses of the industrial effluent discharge to the public sewer are carried out by a registered laboratory. Furthermore, at their own initiative the municipality can perform analyses of wastewater in the effluent from industries or in the sewer network.

Municipalities register new industrial or commercial activities through a number of public databases, e.g. Købmandsstandens Oplysningsbureau (the Danish information agency for retailers).

DEPA launched at the end of the 1990s a national surveillance programme of the water environment (NOVA 2003) with the purpose of monitoring discharge of heavy metals and anthropogenic substances to groundwater and surface water. This implies that major wastewater treatment plants in Denmark now regularly have wastewater samples analysed for the content of heavy metals and anthropogenic substances. Besides providing a national overview it also provides vital information to the operators of the wastewater treatment plants and the characteristics of the wastewater they are receiving. In general, the surveillance programme will improve targeting and regulating sources of heavy metals and anthropogenic substances.

Lead used to be a problem for many wastewater treatment plants in Denmark rendering the sludge unusable for application on agricultural land according to the Statutory Order on Sludge. Part of the exhaust from cars ended on the road surface and was washed with the rain into the public sewers accumulating lead in both the effluents from treatment plants and in the sludge. This problem has been drastically reduced by the introduction of lead free fuel.

In general, many of the interventions against discharge of heavy metals and anthropogenic substances to the public sewer are executed in co-ordination with improved control of industrial and commercial solid waste. Programmes for cleaner technology have among others had the aim of reducing the discharge of heavy metals. At times industries have been forced or convinced to substitute raw material with substances that was a problem to the public sewer system or wastewater treatment.

12.4.2 Economic instruments

The economic instruments used to control wastewater discharge are national wastewater taxes on the amount of discharged nutrients and organic matters.

A sewer fee on water consumption covers all investment costs and operation and maintenance costs for the wastewater sector. A municipality can further impose special taxes for discharge of wastewater to the public sewer, when the wastewater has organic matter and nutrients in higher concentration than normal domestic wastewater.

These economic instruments are not related to public health issues.

12.5 Actors

The public environmental and planning responsibilities concerning wastewater mainly rest with the local and regional authorities. However, some issues are, due to the general or crosscutting character, primarily attended to at state level. This applies for instance for research and the provision of guidance for management procedures and quality criteria.

The primary actors concerning regulation of wastewater are listed in table 12.3. For general descriptions of the mentioned actors please refer to chapter 3.

Table 12.3 Actors, roles and responsibilities concerning wastewater

Actors	Roles and responsibilities concerning wastewater
The Danish Environmental Protection Agency (DEPA)	The Danish Environmental Protection Agency administers the legislation on wastewater and provides guidance for the work of the regional and local authorities and supports research and development.
The medical officer on health	The medical officer on health plays a very central role locally concerning health aspects of access to raw wastewater and contamination of boreholes with wastewater, where they advise counties and municipalities. They are in close contact with the central health and environmental authorities.
Counties	The counties are responsible for regulating discharges to the recipients and for regulations of part of the industries. The counties furthermore prepare the regional plans.
Municipalities	The municipalities are responsible for treatment of wastewater led to the public sewer, for control of industries and discharges, and for preparation of discharge permits. The municipalities furthermore prepare the wastewater master plan.

12.6 Evaluation

The overall health objective of the wastewater regulation is to avoid any harmful impact on public health, whether it be directly (caused by outlet to surface water or soil) or indirectly (leaching to groundwater or inflow to drinking water installations, through application on farmlands or through effects on eco-systems etc.).

The existing wastewater regulation in Denmark has generally succeeded in limiting the public exposure to wastewater. An indicator hereof is that the occurrence of waterborne diseases is much lower in Denmark than in the rest of Scandinavia. The primary reason, however, is mainly due to Danish drinking water supply being based on groundwater, whereas it is primarily based on surface water in the rest of Scandinavia. Only a few cases of drinking water contamination with wastewater have been recorded in recent years in Denmark, and they were caused by flow of wastewater into the water supply network. They did however result in a number of affected persons (as described in chapter 7).

The primary health concern of wastewater is exposure through bathing water. Even though there has been a large reduction in wastewater impact on the water environment for the last ten years (improved wastewater cleaning technology, sharpened discharge requirements, dimensioning of retention basins to minimise overflow etc.), some bathing waters are still influenced by wastewater. The primary impact is caused by overflow of untreated wastewater during heavy rain, but also by run-off from rural areas and from scattered settlements in the countryside not being connected to a wastewater treatment plant.

The Danish Parliament in May 1997 agreed on an action plan for improved wastewater treatment for the scattered settlements in the countryside. The actions will include connection to public wastewater treatment, local sand infiltration plants or small wastewater treatment plants. This action plan will contribute to improvement of the general water quality in fjords, lakes and coastal waters and thereby also contribute to improvements of the bathing water quality.

Important challenges for the wastewater regulation are to improve wastewater treatment for the scattered settlements in the countryside with respect to bathing water quality without creating new problems with groundwater contamination from infiltration of wastewater. Also control and reduction of overflow of untreated wastewater during heavy rain must be in focus.

Even though Danish wastewater treatment plants are very efficient and supply tertiary treatment, they still discharge pathogenic micro-organisms. Therefore it is continuously discussed whether disinfection should be added to the treatment (e.g. by UV-radiation or ozone treatment). If so decided, the monitoring programmes for outlets and bathing waters will also have to be changed, because disinfection will especially decrease the micro-organisms used as indicators today (E. coli etc.).

Another trend to observe is an increasing interest in ecological wastewater treatment with the aim of minimising resource consumption, recirculate nutrients and increase groundwater formation by local infiltration. These techniques should be carefully examined with respect to health impacts.

There is a need for new knowledge in several fields:

- Potential health impacts from effluents from tertiary wastewater treatment.

- Efficiency and consequences of disinfection at wastewater treatment plants.

- Ecological wastewater treatment and health impacts hereof.

- Consequences of new bathing water standards on wastewater management.

- Occurrence of man-made chemicals in wastewater and potential health impacts.

12.7 References

Literature

DEPA (1994): "*Environmental Project no. 25, Økotoksikologiske kvalitetskriterier for overfladevand*" (Ecotoxilogical Quality Criteria for Surface Water).

DEPA (1994): "*Environmental Project no. 260, Industrispildevands miljøfarlighed*" (Environmental toxicity of industrial wastewater).

DEPA (1994): "*Environmental Project no. 188, Økotoksikologisk vurdering af industrispildevand*" (Ecotoxilogical evaluation of industrial wastewater).

DEPA (2000): "*Ecological town planning and wastewater treatment Publication no. 10, Risk of infection from handling of urine, faeces and wastewater.*"

DEPA (1999): "*Environmental Project no. 476, Introduktion til kildesporing af miljøfremmede stoffer i kloaknet*" (Introduction to trace man-made chemical substances in sewers).

DEPA (1999): "*Environmental Project no. 475, Kildesporing af miljøfremmede stoffer i kloaknet*" (published only on DEPA's homepage) (Tracing of man-made chemical substances in sewers).

DEPA (1993): "*Environmental Project no. 245, Tilslutning af industrispildevand til kommunale renseanlæg*" (Connection of industrial wastewater to municipal wastewater treatment plants).

DEPA (1994): "*Environmental Project no. 278, Miljøfremmede stoffer i renseanlæg*" (Man-made chemical substances at wastewater treatment plants).

DEPA (1991): "*Spildevandsforskning fra Miljøstyrelsen no. 21, Hygiejnisk kvalitet af spildevand fra renseanlæg*" (Sanitation quality of wastewater from wastewater treatment plants).

DEPA (1993): "*Spildevandsforskning fra Miljøstyrelsen no. 51, Hygiejnisering af renset spildevand*" (Sanitation in treated wastewater).

Stenström, T.A. (1996): "*Sjukdomsfremkallande mikroorganismer i avloppssystem - riskvärdering av traditionella och alternative avloppslösninger*". Naturvårdsverket. Rapport, 1996.

Bukhari, Z, Smith, H.V., Sykes, N., Humphreys, S.W., Paton, C.A., Girdwood, R.W.A., Fircker, C.R. (1997): "*Occurence of Cryptosporicium spp oocysts and Giardia spp cysts in sewage influents and effluents from treatment plants in England*". Wat. Sci. Tech., 35, 11-12, 385-390.

Nordisk Ministerråd (1994): "*Vattenburna infektioner i Norden*", TemaNord 585, ISSN 0908-6692. (Waterborne infections in the Nordic Countries).

Danish Legislation

The Planning Act: Act no. 518 of 11 June 2000.

The Environmental Protection Act: LBK no. 698 of 22 September 1998.

Statutory Order on discharge permits according to chapters 3 and 4 of the Environmental Protection Act (no. 501, 21 June 1999).

Statutory Order on quality criteria for wetlands and criteria for discharge of certain dangerous substances to streams, lakes or the sea (no. 921, 8 October 1996).

Statutory Order no. 49 of 20 January 2000 on use of waste products for agricultural and related purposes (the "Sludge Order").

Guideline for discharge of industrial effluent to municipal wastewater treatment plants, no. 6/1994.

13 Noise

Noise is the environmental factor that affects most people. Many people complain about noise and noise is given great attention in the public.

Since the first Environmental Act came into force in 1974, actions to reduce noise have been part of Danish legislation.

13.1 Human exposure to environmental noise

13.1.1 Environmental factors

Several sources contribute to environmental noise. The physical properties of environmental noise can be described by:

- the frequency content of the sound
- the overall sound pressure level
- the duration of the sound
- the variation of these with time

Environmental noise can consist of e.g. continuous noise, tonal noise, impulsive noise and low frequency noise from various sources.

Different frequency weightings and time weighting constants are used in noise measurement to obtain a measure that relates to the human perception of the noise. Usually a long-term average of the A-weighted[103] sound pressure level, LAeq, is used to describe environmental noise.

13.1.2 Sources

A number of sources contribute to the environmental noise in the community. The most important sources are:

- Road traffic, especially on major urban roads in built up areas. All roads with an average annual traffic volume about 1,000,000 vehicles may cause noise impact above current guideline values

- Railway traffic

- Plant and machinery on industrial and commercial premises

- Airports

- Shooting ranges and motor racing tracks

- Wind turbines

[103] A-frequency weighting. Frequency weighting of a spectrum according to a standardised frequency response curve that approximates the human hearing system.

- District heating stations and power plants
- Construction sites

13.1.3 Human exposure

Recent environmental noise mappings show that ½-1 million people out of a total population in Denmark of approximately 5 million are suffering from high noise impact. As traffic noise is the main source of annoyance, much effort has been spent on mapping and evaluating possible actions to limit the number of people annoyed by traffic noise. In 1993, the Danish government decided that the number of housing units exposed to more than 65 dB(A) from traffic should be decreased from 130,000 to 50,000 before 2010.

In 1993, a national noise mapping study related to criteria values was carried out showing that

- approximately 485,000 housing units were exposed to more than 55 dB(A) from road traffic and hereof 145,000 to more than 65 dB

- approximately 40,000 housing units exposed to more than 60 dB from rail traffic, hereof 14,000 to more than 65 dB. Half of the housing units are located in the Copenhagen area and the rest along the 1,100 km of the main railway network

- approximately 40,000 housing units exposed to more than 55 dB(A) around airports, hereof 3,000 to more than 65 dB. The main part is located around Copenhagen Airport Kastrup.

Similar figures are not available on noise from other sources. A best estimate from the DEPA on exposure from other sources will be:

- approximately 40,000 housing units are exposed to levels above the limit values for noise from industrial plants etc.

- approximately 40,000 housing units are exposed to levels above the criteria values for noise from other commercial premises such as workshops, shops, restaurants etc.

- approximately 15,000 housing units are exposed to levels above the criteria values for noise from leisure time activities such as shooting ranges and motor sport ranges

13.2 Level of protection

Environmental noise in Denmark is usually so low that it is not likely to cause serious human damage like hearing impairment. However, environmental noise is annoying and may have adverse effects such as:

- interference with speech communication,
- performance and productivity,
- disturbance of rest and sleep and
- physiological and mental health effects like stress, hypertension, ischemic heart disease

In the 1970s and the early 1980s, dose and effect studies have been carried out in Denmark on a national scale, which show the relationship between the level of annoyance and the average noise.

Different kinds of noise have different kinds of effects, as annoyance is subjective. Noise annoyance is highly dependent on different noise sources, frequency spectrum, and relation to the noise source and on personal expectations. Many people living in down town areas in big cities like Copenhagen do not expect tranquillity. Even the duration and variation over time of noise is important when transforming sound propagation into annoyance.

Until now focus has been on annoyance, but also sleep disturbance shall be included in future regulation.

Danish examples of criteria values for road traffic noise are summarised in the following table.

Table 13.1 Danish examples of criteria values for road traffic noise (LAeq, 24h)

Area type/utilisation	Criteria value	
	General	Densely built-up areas
Recreational areas	50	-
Day-care centres	55	65
Hospitals	55	-
Educational establishments	55	-
Dwellings	55	55
Hotels	60	70
Office blocks	60	70

(Ref.: Guideline no. 3/1984 on noise from road traffic)

Present guidelines and criteria values for traffic noise express a compromise between high quality of life and socio-economic considerations (technical, economical and community aspects), accepting that a minor part of the public (typical the 10% most noise sensitive people) might still feel highly annoyed.

The purpose of the present guideline values is to ensure satisfactory environmental conditions.

Increasing attention is put on preserving areas where people can still experience silence and tranquillity. In local and regional planning, focus shall be on preserving such areas.

13.3 Regulation and strategies

13.3.1 Objectives and principles

In the objects clause of the Danish Environmental Act is stated, among other things, that the act shall prevent and abate noise impact on the public.

Sufficient scientific evidence on noise annoyance is still lacking for some types of noise.

No Danish research on dose and effect relationship has been carried out recently. DEPA did carry out investigations in 1985 and 1995 on annoyance due to noise from railway traffic and shooting ranges respectively as part of the development of guidelines on these noise sources.

In mid-1990, a pilot study was carried out on noise from wind turbines as part of a common European Study.

DEPA has asked for analyses on current knowledge on annoyance due to activities on military fields and on annoyance due to impulse and low frequency noise. These investigations have not been finalised.

This year, both the European Commission and WHO have published state-of-the art on dose and effect relationship. The relevance of these studies for Danish conditions and their possible influence on Danish guideline values have not been investigated yet.

Knowledge on annoyance due to industrial noise is limited. Present guidelines are based on available investigations at the time the guidelines were published. However, present experience has shown that the guideline values seem fair.

Future dose/effect relationships are expected to be based on common European studies, possibly complemented by minor Danish studies to confirm European findings.

Part of the Danish approach to noise control and abatement is to deal with noise in most planning regulations i.e. the Danish Planning Act.

At the same time, environmental noise (e.g. from roads and railways) is an integrated part of Danish Building Regulations to ensure low noise impact inside dwellings in connection with construction of new buildings in noisy surroundings.

The main principle of the Danish Noise Abatement is the polluter pay principle. That means that all new enterprises within specific categories require environmental approval before initialisation. For public infrastructure, noise considerations have to be carried out as part of the Environmental Impact Assessment study. For new enterprises and public infrastructure, all costs regarding planning and construction of the necessary noise abatement is conducted by the polluter according to the above mentioned principles. There are no guidelines for noise abatement regarding traffic noise from existing roads and railways in existing urban areas. The consequence is that the majority of people annoyed by traffic noise are within housing areas in the bigger cities.

In July 2000, the Commission presented a proposal for a Directive on the Assessment and Management of Environmental Noise COM(2000) 468final. The main objective of the proposed new EU Noise Policy is to provide a basis for a coherent integrated EU noise policy. The idea is to make EU-wide noise maps based on common prediction methods and indicators. The maps shall be made available to the public and form the basis for development of action plans and strategies at local, national and EU levels to combat noise pollution.

13.3.2 Legislation on noise abatement

The EU regulations on noise deal with emission from a number of sources covering traffic vehicles, outdoor machinery etc. These regulations have been implemented in the Danish legislation.

Presently, the Danish approach to noise is to focused only on the source, but also on good land-use planning to ensure sufficient distance between noise sources and noise sensitive areas.

A number of Danish Guidelines provide criteria values on noise from most sources. The guideline values have been set to ensure that the majority of the public does not feel any nuisance unless these guideline values are exceeded. Furthermore, a number of best practice manuals are listed below.

Text box 13.1 Acts and guidelines concerning Danish Noise Requirements

Environmental Protection Act, latest revised in Statutory order no. 698 of 22 September 1998. This act deals with all environmental matters.

Planning Act, no. 551 of 28 June 1999. This act regulates all new urban and infrastructure development.

Guideline no. 3/1984 on noise from Road Traffic containing guideline values differentiated on the type of receiver: residential areas, offices, schools recreational areas, etc.

Guideline no. 1/1997 on noise from Railway Traffic setting guideline values for LAeq on a 24 hours level and LAmax levels for different types of land use.

Guideline no. 5/1994 on noise around Airports setting guideline values for day, evening and night.

Local Act on Development of Copenhagen Airport Kastrup; Act no. 271 of 16 June 1980, revised in Act no. 241 of 8 April 1992.

Statutory order no. 821 of 23 October 1997 on noise from high speed ferries (dealing both with A-weighted values and low frequency regulations)

Guideline no. 5/1984 together with no. 3/1996 on noise from plants and machinery on industrial and commercial premises.

Orientation no. 9/1997 on low frequency noise and vibrations.

Noise from auto repair shops, Statutory order no. 922 of 5 December 1997.

Noise from wind turbines; Statutory order no. 304 of 14 May 1991.

List of industries/plants forced to have n environmental approval; Statutory order no. 807 of 25. October 1999 and amendment no. 107 of 1 February 2000.

Guideline no. 3/1997 on noise around motor sport ranges.

Guideline no. 1/1995 on noise from shooting ranges.

Statutory Order no. 1057 of 14 December 1998 Ministry of the Environment *"Bekendtgørelse om støjregulering af forsvarets øvelsespladser og skyde- og øvelsesterræner"*. Management of noise around military shoot ranges and training fields, aiming at preventing and decreasing noise and vibrations from activities on military training fields.

Regulation on sources
The Danish Road Safety and Transport Agency is responsible for legislation and enforcement on road traffic. The tasks include among other things:

- The planning of driver education and tests.
- Matters concerning driving licences, and road safety and development tasks in relation to road users.
- Matters concerning the technical design of vehicles.
- Type approval of vehicles.
- Regulations on vehicle inspection and the registration of vehicles

The Statutory order no. 366 of 10 May 1992 enables local environmental authorities to lay down regulations on the max time for idling of vehicles, on noise from household machinery and noise from ventilation units.

Presently a new EU Directive on outdoor noise sources is being implemented.

13.4 Instruments

13.4.1 Regulatory instruments

Reduction of environmental noise has as its main purpose to improve the public health and social well-being and avoid or minimise sleep disturbance and other annoyance.

The regulations on noise encompass the enforcement of acts, orders and guidelines by environmental approvals and injunctions.

Environmental approval of airports, industrial premises, shooting ranges and motor racing tracks are handled by the municipalities or counties. In special cases, DEPA is the authority for environmental approvals. As part of most environmental approvals, noise mapping at various levels is done to ensure that the noise regulations are met.

13.4.2 Planning instruments

The Danish Planning Act deals with noise considerations as an integrated part of new or changed land use and infrastructure planning. The objective of the Act is to ensure that no new noise problems arise.

National noise mapping has been carried out along the major roads by the Danish Road Directorate and for main railways by the Danish National Railway Agency (see figure 13.1).

Some major municipalities and cities and counties have made noise mapping for road traffic noise as part of their Environmental Action Plan.

- Mapping showing the amount and location of the main environmental noise problems
- Action planning, time schedules and priority
- Selection of abatement measure (and cost-effectiveness analyses)

The mapping has been followed by action planning to control present noise problems and set up noise impact areas, such as roads, railways, airports and industrial plants to avoid new noise sensitive land use, e.g. residential areas located too close to noise sources.

In developing new infrastructure, noise shall be considered as part of the Environmental Impact Assessment (EIA) with the county or the Danish government as the authority.

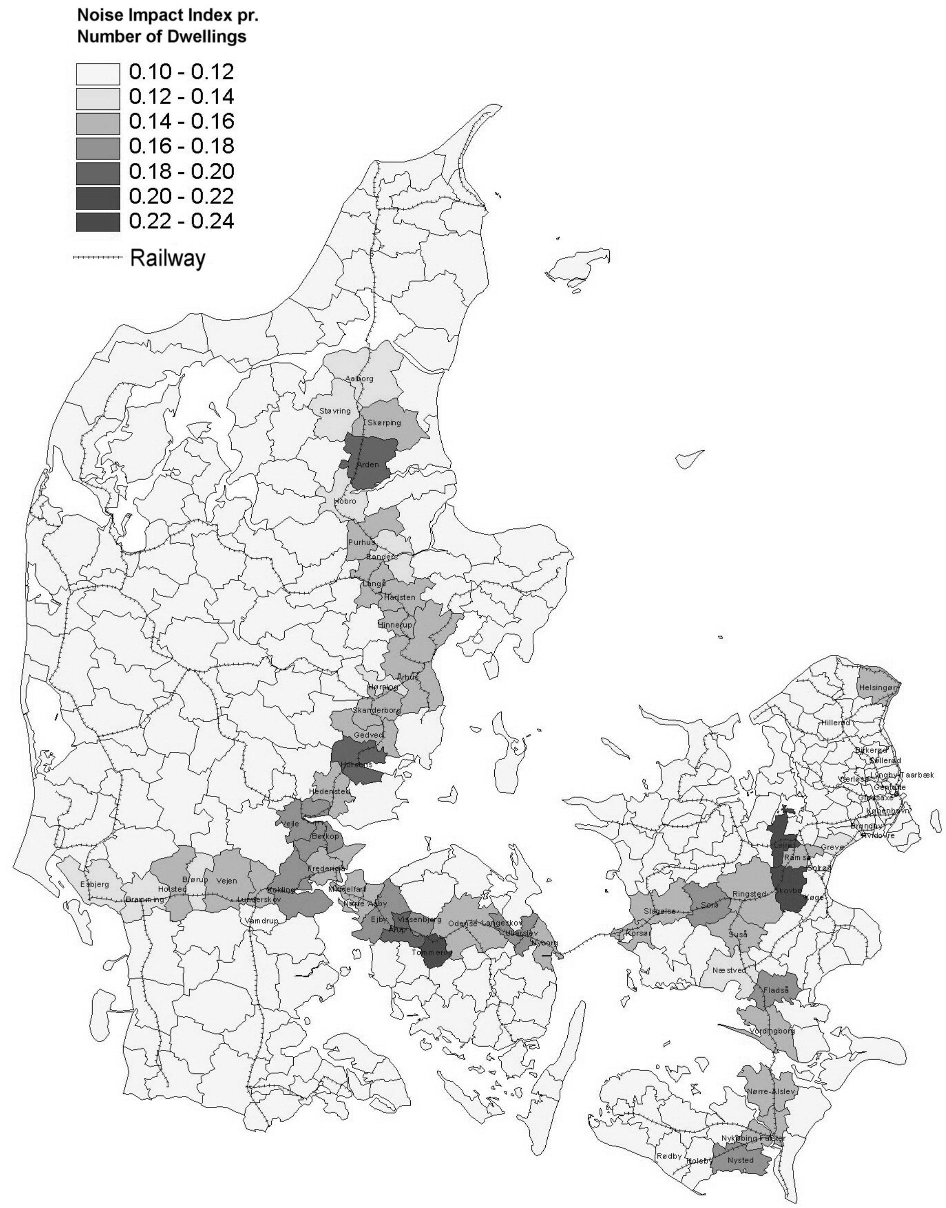


Figure 13.1 National noise mapping study showing noise impact in relation to the total number of exposed dwellings for Local Counties along the Danish Railways.

13.4.3 Economic instruments

The main principle is still the polluter-pay-principle. That means that abatement measures necessary to reduce noise from industrial or leisure time activities have to be carried out and paid by the one responsible for the actual noise sources.

Concerning noise from air traffic, the airport authorities are responsible for the environmental approval of the airport and the necessary measures to meet approved values. Furthermore, the airport authorities can put a noise fee on noisy aircraft as part of the landing fees.

For most other types of traffic noise funding for environmental noise abatement come from national and regional tax revenues. At local level, only a smaller amount of money has been used on noise abatement up till now.

The Road Safety and Transport Agency is responsible for development tasks concerning environmentally friendly technologies for vehicles and public transport. Since 1995, the Agency has administrated the part of the Ministry of Transport Road Traffic Pool used to develop and test environmentally friendly technologies.

13.5 Actors

A number of actors are sharing the responsibility to ensure a high noise standard (meaning low noise) in Denmark.

Table 13.2 Actors, roles and responsibilities concerning noise

Actors	Roles and responsibilities concerning noise
The Danish Environmental Protection Agency (DEPA)	DEPA administers the legislation on environmental noise. DEPA provides guidance for the work of the regional and local authorities and supports research and development. DEPA is responsible for the continuous elaboration and updating of the national guidelines. Furthermore, DEPA serves as an appeal agency in conjunction with environmental approvals.
Agencies	The Danish Road Directorate, Danish National Railway Agency, the Civil Aviation Administration. These agencies are responsible for the provision of information on traffic data. National noise mapping is carried out along the major roads by the Danish Road Directorate and for main railways by the Danish National Railway Agency.
Counties and municipalities	Environmental approval of airports, industrial activities, shooting ranges and motor racing tracks are handled by the municipalities or counties. The counties and municipalities are responsible for regional and local action planning.
Municipalities	The major municipalities and cities are doing noise mappings for road traffic noise as part of their Environmental Action Plans.
Private actors	Private actors will be industrial and commercial companies, airport authorities, many sport clubs, equipment manufacturers, consumers and the public. All private actors shall comply with the national guidelines even if they are not compulsory to have an environmental approval.

13.6 Evaluation

Present guidelines and criteria values express a compromise between high quality of life and socio-economic considerations (technical, economical and community aspects), accepting that a minor part of the public (typically the 10% most noise sensitive people) might still feel highly annoyed.

The latest national noise mapping in Denmark in 1993 showed the following figures on houses exposed above the guideline values:

- approx. 485,000 housing units are exposed to more than 55 dB(A) 24 hours equivalent level from road traffic, hereof 145,000 exposed to more than 65 dB(A)

- approx. 40,000 housing units are exposed to more than 60 dB(A) 24 hours equivalent level from rail traffic, hereof 14,000 to more than 65 dB(A)
- approx. 40,000 housing units are exposed to more than 55 dB(A) DEN[104] 24 hours around airports, hereof 3,000 to more than 65 dB(A)

In addition, DEPA estimates based on a small number of mappings around major industrial plants show that approx. 40,000 housing units are exposed above the guideline values from industry. A similar number of housing units are exposed to noise above the guideline values from other commercial premises, bars and restaurants, shops etc. Finally, DEPA estimates that a minor number of houses are exposed to noise from leisure time activities like shooting ranges, motor sport ranges, etc.

It is evident that traffic is the main environmental noise source. Present legislation gives no obvious provisions to control or reduce traffic noise, except around airports that have to obtain an environmental approval before getting into operation.

This means that the only way to control and reduce traffic noise will be by good land use and infrastructure planning. Recently local authorities have carried out Traffic and Environmental Plans to manage traffic and reduce the environmental impact.

The European Union presents in short time a new "Directive on Assessment and Management of Environmental Noise" dealing with noise mapping and action planning, common indicators and information to the public. It is foreseen that this directive will put further focus on noise and the need for measures to control and reduce noise impact.

The future challenge will be to achieve real progress in noise control with increasing traffic and intensive use of outdoor machinery. In the cities, the use of the areas is changing. A Committee on Commercial, Industrial and Town Policy is developing policies on turning abandoned commercial areas into housing areas without creating further environmental problems and as part of that ensure that necessary considerations on noise are taken into account in urban planning.

New research has to be carried out. Among relevant studies investigations have to be made on dose and effect relationship, especially on noise from industry, and indicators have to be defined to describe silence and tranquillity for local and regional planning of relatively quiet areas. Another challenge to be faced in the future is an analysis of the implications of strengthened noise limits for the various sources, which would protect an even larger share of the population against annoyance and health effects due to environmental noise.

[104] Lden is an indicator of noise level during the day, evening and night based on the ‘long-term average’ LAeq for the periods 07.00-19.00 (day); 19.00-23.00 (evening); 23.00-07.00 (night). The indicator is obtained by energy-averaging the three periods after applying a 5 dB penalty to the evening period and a 10 dB penalty to the night period.

13.7 References

Literature

Lydteknisk Laboratorium (Technical Sound Laboratoty) Report no. 5, (1977) "*Reactions to road traffic noise in correlation to the physical measures of the noise.*"

DEPA (1980): "*Reactions to road traffic noise*". Environmental project no. 23.

Vejdirektoratet (The Road Inspectorate) (1985): "*Considerations to road traffic noise with planning and construction of new roads.*"

DEPA (1992): "*Reactions to railway noise in Denmark, Environmental project no. 42 and paper in Journal of Sound and Vibration 1988.*"

Eystein Amtzen (1984): "*Annoyance caused by shooting noise.*"

The Ministry of Transport (1993): "*Traffic 2005.*"

WHO, Birgitta Berglund et al. (1999): "*Annoyance caused by shooting noise, Guidelines for Community Noise.*"

Danish legislation

The Environmental protection Act, consolidated 1997.

The Danish Planning Act, Consolidated Act no. 746 of 16 August 1994.

EU legislation

Proposal for a Directive on the Assessment and Management of Environmental Noise COM (2000)468final presented in Bruxelles 27 July 2000.

Principles for derivation of health based guidance values and quality criteria for chemical substances

In the following, the principles upon which the Danish Environmental Protection Agency derive health based guidance values and quality criteria for chemical substances are briefly outlined. The quality criteria are nationally derived criteria values, as the Minister of the Environment according to the environmental protection law is authorised to stipulate quality criteria for the protection of environment and health.

The quality criteria for air, soil and drinking-/ groundwater are supplementary values derived by the Danish EPA in areas where no quality standards/ limit values have been implemented by statutory orders. Thus the quality criteria are guidance values, for which deviation can be made in specific cases if this does not compromise the protection of human health.

Purpose
The purpose of setting health based guidance values and quality criteria for chemical substances is to prevent health hazards in the human population caused by chemicals as pollutants. The scientific method for setting of health based guidance values comprises a hazard identification and hazard assessment which together with an exposure assessment constitute the risk assessment part in the process.

Selection of data
Data concerning exposure and harmful effects of a chemical substance are collected from national and international criteria documents, monographs and original scientific literature. During the review of the data, the quality and reliability of the studies and research work are critically assessed. This is an important step since conflicting viewpoints regarding the hazards may be present. Unpublished data from industry or other sources are only seldom used, as such data have not been published in scientific journals and have not been subjected to critical review by other scientists.

If adequate human data are available these are preferred as the basis for the assessment. For most substances however, human data are not adequate or available. In these cases, health based objective values are based upon data from experimental animal studies.

When all the relevant data have been evaluated, the hazard considered most important - "the critical effect" - for setting the health based guidance value, is identified. In this step it is assessed whether an effect should be considered as adverse and of relevance to humans.

A substance may have different effects at different concentrations or doses. Generally, the effects are of more concern the lower the concentration or dose at which they occur, and the effect observed at the lowest concentration or dose often forms the basis for setting the guidance value.

Threshold chemicals, NOAEL or LOAEL

The next step for assessment of a health based guidance value is to identify the "no observed adverse effect level" (NOAEL) which is the highest dose at which the critical effect was not observed or, in cases where a NOAEL cannot be identified, the "lowest observed adverse effect level" (LOAEL) which is the lowest dose at which the critical effect was observed.

TDI / safety factors

Having identified a NOAEL or a LOAEL, three "safety factors" (SF) are used to extrapolate from NOAEL or LOAEL to the tolerable daily intake, TDI (expressed in mg/kg b.w. per day) or the tolerable concentration in air, TC_{air}, (expressed in mg/m^3). The purpose of the safety factors is to take into account the fact that:

SF_1: The toxicological effect of a chemical substance on animals need not reflect the toxicological effect on "normal" humans, this factor is historically set at 10.

SF_2: The toxicological effect of a chemical substance may vary considerably between different persons, and that i.e. children, elderly or sick people may be much more sensitive to exposure than "normal" people, this factor is often set at 10.

SF_3: The data may be of varying quality and relevance to the actual problem, this factor is set at a value from 1 to 1000 depending on a concrete evaluation.

Thus in cases where a threshold value for the toxic effect is assumed and a NOAEL or a LOAEL can be identified, the TDI (or TC) are obtained by the following calculation:

$$\text{TDI (TC)} = \frac{\text{NOAEL(C) or LOAEL(C)}}{SF_1 \times SF_2 \times SF_3}$$

Exposure routes

In general, guidance values for air are based upon data from inhalation studies and guidance values for soil (GV_{soil}) and drinking water (GV_{dw}) are based upon data from oral studies. However, if data for the relevant exposure route are not available, data from alternative exposure routes may be used as well, although it is realized that the degree of uncertainty may increase. This will then influence the value of the SF_3.

Analogy
In cases where no data on harmful effects are available, an evaluation may be made upon the basis of data for related substances and a consequent increase in the value of the SF_3.

Non threshold chemicals
For chemical substances where a threshold value for the toxic effect cannot be assumed (i.e. genotoxic carcinogenic substances), the concept of lifetime risk is applied. Thus, for these potential carcinogenic substances, the TDI corresponding to a specific lifetime risk, is calculated upon the basis of animal studies by means of the "One Hit" model. A lifetime risk of 10^{-6} (life-time exposure to the dose that may lead to cancer for one in a million) is considered as tolerable.

Exposure
air, water, soil
Having obtained the tolerable daily intake (or concentration) for a chemical substance, the health based guidance values for drinking water and soil are calculated taking into account the daily exposure from the various media. The following exposure standard estimates for the various media are used in the calculation of guidance values:

	Soil* oral intake	**Soil* Dermal contact**	**Air Inhalation**	**Water oral intake**
Child, 10 kg				
average exposure	0.2 g/d	1 g/d	10 m^3/d	1 liter/d
maximum exposure	10 g/d	10 g/d	12 m^3/d	2 liter/d
Adult, 70 kg				
average exposure	0.025 g/d	0,1 g/d	20 m^3/d	2 liter/d
maximun expsoure	0.1 g/d	1 g/d	30 m^3/d	4 liter/d

*For the soil exposure estimates, it has to be emphasized that these are based upon exposure scenarios which cover the most sensitive applications, e.g. domestic gardens, play grounds or kindergartens.

To ensure that the total daily intake of a chemical substance from the various media does not exceed the tolerable daily intake, a certain percentage of the tolerable intake to the various media may be assigned (allocation).

Health based guidance values
The guidance values for soil and drinking water are obtained by the following calculations:

$$GV_{soil} = \frac{TDI^{\star} \times w_{child}}{ingestion_{soil}}$$

$$GV_{dw} = \frac{TDI^{\star} \times w_{adult}}{ingestion_{dw}}$$

$$GV_{air} = TC_{air},$$

if the concentration is the critical parameter e.g. in relation to airborne irritants, or

$$GV_{air} = \frac{TDI^{\star} \times w_{adult}}{inhalation_{air}}$$

if the dose delivered through the air is the critical parameter e.g. in connection with substances systemic effects.

TDI*: often only a certain percentage (typically 10%) of the TDI is allocated to the calculation of the quality criteria, as this procedure account for exposure contributions from other media, e.g. exposure from food or exp osure from every day chemical pro ducts are considered.
w: body weight for a child (10 kg) or an adult person (70 kg)

C-value, quality criteria
Finally, the health based guidance values are used as the basis for the setting of quality criteria for soil, drinking water, ground water, and air (known as "C-values", which are contribution emission concentration values for air pollutants from industrial plants). In this step, other considerations than health based aspects may be taken into account. This may include aesthetical factors such as odour (all media), discoloration (soil, drinking water), or taste (drinking water). Furthermore, economic or political administrative factors may be taken into account as well.

It has to be stressed that no eco-toxicological considerations are taken into account in the process of setting health-based guidance and quality criteria values.

List of Danish soil quality criteria values and the corresponding groundwater quality criteria, air quality criteria and cut-off values.

The quality criteria values and cut off values are nationally derived guidance values. *Soil quality criteria* are health-based values derived to secure most sensitive use of the soil i.e. domestic garden, kindergartens and playgrounds. Especially direct soil-exposure of small children is considered. In addition to these health based criteria it is an overall quality demand that the soil by inspection must not look contaminated or possess odour from soil pollutants.

In the interval between the soil quality criteria and the *cut-off value,* the soil can only be used for most sensitive use if the local authorities inform and advise the public and the land owner with respect how to establish hygienic measures and soil-exposure reduction measures in a way that the risk for harmful effects is not increased. Cut-off values have only been made for some immobile and rather persistent chemicals (metals and polyaromatic hydrocarbons).

The *groundwater quality criteria* are used in connection with groundwater-protection, as groundwater is the major drinking-water resource in Denmark. The starting point for derivation of *groundwater quality criteria* are the nationally derived *drinking water quality criteria* (or the drinking water standards which are mandatory values following the implementation on the EU-directive on drinking-water quality). The ground-water quality criteria are for some substances set at a lower level than the drinking-water quality criteria, because account has to be taken to additional chemical sources in connection with water treatment procedures and releases of contaminants from the distributing system before the water reach the consumer as drinking-water.

The *air quality criteria* are used as criteria for evaporation of the soil pollutant into indoor air. The air quality criteria are only meant to consider the *contribution* from the evaporation of the contaminated soil and thus are <u>not</u> meant as overall quality criteria for indoor air.

The quality criteria for the different media are independent criteria, and therefore compliance with the soil quality criteria does not automatically ensure compliance to the quality criteria for evaporation to indoor air or leakage into the groundwater, i.e. each of the relevant criteria has to be considered separately.

The following list is based on values published earlier (see references below) together with the addition of new values not published earlier.

Chemical name	CAS-no	Soil quality criteria mg/kg	Soil cut off values mg/kg	Ground-water quality criteria µg/ l	Evaporation to indoor air, Air quality Criteria mg/m^3
Acetone	67-64-1	-	-	10	0.4
Acrylonitrile	107-02-8	0,1	-	0,1	0.00004
Aromatic hydrocarbons $\geq C_9$, total	-	-	-	-	0.03
Arsenic	-	20	20	8	-
Benzene	71-43-2	1,5	-	1	0.00013
Benzotriazole (+ tolyltriazole)	95-14-7	30	-	-	-
Boron, inorganic	-	-	-	300	-
Butyl acetate (n-, iso-)	123-86-4 110-19-0	-	-	10	0.1
Cadmium	-	0,5	5	0,5	-
Chloroform	67-66-3	50	-	-	0.02
Chlorinated solvents	-	-	-	1	-
Chlorophenols (sum of mono- ,di- , tri-, and tetra-)	-	3	-	0,1	2×10^{-5}
Chromium (IV) Chromium (III + VI)	-	20 500	- 1000	1 25	-
Copper	-	500	500	100	-
Cyanides, inorganic (total) Cyanide drive off by acidization	- -	500 10	-	-	 0.06
DDT + DDE	50-29-3, 72-55-9	0,5	-	0.1	-
Di-(2-ethylhexyl) phthalate, DEHP	117-81-7	25	-	1	-
1,2-dibromoethane	106-93-4	0,02	-	0,01	2×10^{-6}
1,2-dichloroethane	107-06-2	1	-	1	1×10^{-4}
1,1-dichloroethene	75-35-4	5	-	1	0.01
1,2-dichloroethene (*cis + trans* isomers)	156-59-2 156-60-5	85	-	1	0.4
Dichloromethane	75-09-2	8		1	0.0006
1,2-Dichloropropane	78-87-5	5	-	1	0.0005
Diesel fuel, fuel oil, Total hydrocarbons Aromatic hydrocarbons, $C_9 + C_{10}$ PAH	-	- 100 - See PAH	- - - see PAH	- 9 - see PAH	- - 0.03 -
Diethyl ether	60-29-7	-	-	10	1
Dinitrophenoler	25550-58-7	10	-	0,5	0.005

Chemical name	CAS-no	Soil quality criteria mg/kg	Soil cut off values mg/kg	Ground-water quality criteria µg/ l	Evaporation to indoor air, Air quality Criteria mg/m^3
Fluorides, inorganic	-	20	-	-	-
Formaldehyde	50-00-0	75	-	-	0.001
Furfural	98-01-1	40	-	-	0.002
Gas oil, C_5-C_{35} hydrocarbons	-	100	-	9	-
Gasoline Hydrocarbons, C_5-C_{10} Benzene C_9-C_{10} aromatics 1,2-dibromoethane	 71-43-2 106-93-4	 25 1,5 0,02	- - - - -	- 9 1 - 0,01	- - 0.00013 0.03 2 x 10^{-6}
Isopropanol	67-63-0	-	-	10	1
Lead, inorganic	-	40	400	1	-
Lithium, inorganic	-	500	-	-	-
Mercury, inorganic	-	1	3	0,1	-
Molybdenum, inorganic	-	5	-	20	-
Methyl-*tert*-butyl ether, MTBE	1634-04-4	500	-	30	0.03
Methyl isoamyl ketone	110-12-3	-	-	-	0.005
Methyl isobutyl ketone	108-10-1	-	-	10	0.2
Mononitrophenols	-	125	-	0,5	-
Naphthalene	91-20-3	-	-	1	0.04
Nickel	-	30	30	10	-
Nitrobenzene	98-95-3	5	-	-	0,0002
Nonylphenol	84852-15-3	25	-	-	0.005
Nonylphenolethoxylates	-	65	-	-	-
Pentachlorophenol	87-86-5	0,15	-	-	1 x 10^{-6}
Pesticides, total Pesticides, single Pesticides, chlorinated persistent	-	-	-	0.5 0.1 0.03	-
Phenols (total) Phenol, Cresols, Xylenols	-	70	-	0,5	 0.02 0.003 0.002
Phthalates (not DEHP)	-	250	-	1	-
Polyaromatic hydrocarbons, PAH Benzo(*a*)pyrene Dibenzo(*a,h*)anthracene	-	1,5[a] 0,1 0,1	15[a] 1 1	0,2[b]	-
Silver, inorganic	-	50	-	-	-
Styrene	100-42-5	40	-	1	0.2
Tensides, anionic	-	1500	-	-	-

Chemical name	CAS-no	Soil quality criteria mg/kg	Soil cut off values mg/kg	Ground-water quality criteria µg/ l	Evaporation to indoor air, Air quality Criteria mg/m^3
Tetrachloroethylene	127-18-4	5	-	1	0.0002
Tetraethyllead + Tetramethyllead	78-00-2, 75-74-1	4	-	-	0.0003
Thallium, inorganic	-	1	-	-	-
Tin	-	500	-	-	-
Toluene	108-88-3	-	-	5	0.4
Tolyltriazole (+ benzyltriazole)	29385-43-1	30	-	-	-
1,1,1-trichloroethane	71-55-6	200	-	1	0.5
Trichloroethylene	79-01-6	5	-	1	0.001
Tricresylphosphates, total *o*-TCP	-	350 15	-	-	-
Trinitrophenoles	-	30	-	0,5	0.005
Vinyl chloride	75-01-4	0,4	-	0,3	4×10^{-5}
White spirit/ Stoddard solvent Total hydrocarbons (C_7-C_{12}) C_9-C_{10}-aromatics	-	- 25 	-	- 9 	 0.03
Xylene	1330-20-7	-	-	5	0.1
Zink	-	500	1000	100	-

a: in soil, sum of benzo(*a*)pyrene, benzo(*b+j+k*)fluoranthene, dibenzo(*a,h*)anthracene, fluoranthene, and indeno(*1,2,3-cd*)pyrene

b: in water, sum of benzo(*a*)pyrene, benzo(*b+k*)fluoranthene, fluoranthene, indeno(*1,2,3-cd*)pyrene, and benzo(*ghi*)fluoranthene

Comments:

It should be noted that the soil quality criteria are health based values, and for some substances with low odour threshold (e.g. MTBE) the soil quality criteria may not comply with the overall quality objective that the soil should appear clean and be without odour from soil pollutants.

Some of the groundwater quality criteria may be subject to revision in order to cohere with proposals for new drinking water standards. Especially for MTBE, the groundwater quality criteria value is expected to be lowered.

<u>References:</u>

DEPA (1999): "*Toxicological evaluation and limit values for methyltert-butyl ether (MTBE), formaldehyde, glutaraldehyde and furfural.*" Environmental project no. 511.

DEPA (1999): "*Toxicological evaluation and limit values for nonylphenol, nonylphenol ethoxylates, tricresyl phosphates and benzoic acid.*" Environmental project no. 512.

DEPA (1995): "*Toksikologiske kvalitetskriterier for jord- og drikkevand*". (Toxicological quality criteria for soil and drinking water) Project no. 12.

DEPA (1996): "*B-værdier*" (C-values). Guideline no. 15.

DEPA (1998): "*Oprydning på forurenede lokaliteter*" (Remediation of contaminated sites). Guideline no. 7

DEPA (1990): "*Begrænsning af luftforurening fra virksomheder*" (Reduction of air pollution from industries), Guideline no. 6.

Drinking water quality criteria

The following list contain nationally derived drinking water quality criteria for selected substances which are not covered by drinking water standards in connection with the implementation of the EU directive on drinking water quality.

It should be noted that the drinking water quality criteria are health based values based on a toxicological evaluation of the specific compound, i.e. no consideration has been made to the risk for microbial growth. The risk for microbial growth should be considered as well, as this may be relevant for organic substances having high drinking water quality criteria values.

Most of the values have been published in the publications given below, however, the table also includes some new values not published before.

Chemical name	CAS-no	Drinking water Quality criteria µg/ l
Acetone	67-64-1	2000 /L
Benzotriazole (+ tolyltriazole)	95-14-7	20
Butyl acetate (n-, iso-)	123-86-4 110-19-0	10 /L
Chlorophenols (sum of mono- , di- , tri-, and tetra-)	-	0,1
Cyanide, driven off by acidization	-	10
Diethyl ether	60-29-7	40 /L
Dinitrophenoler	25550-58-7	7
Furfural	98-01-1	3
Isopropanol	67-63-0	300
Lithium, inorganic	-	1000
Methanol	67-56-1	3500
Methyl isoamyl ketone	110-12-3	10
Methyl isobutyl ketone	108-10-1	100 /L
Molybdenum	-	20
Mononitrophenols	-	90
Nitrobenzene	98-95-3	4
Tetraethyllead + Tetramethyllead	78-00-2, 75-74-1	3
Thallium, inorganic	-	1
Tolyltriazole (+ benzyltriazole)	29385-43-1	20
Tricresylphosphates, total *o*-TCP	-	250 10
Trinitrophenoles	-	20

/L : the value based on data on odour/taste that is considered most critical.

Comments:
It is an overall quality demand that the drinking water visually appears clean and is without any untoward taste or odour. Furthermore a content of organic constituents in the water may not constitute a media for microbial growth. Generally, microbial growth is not expected to occur with a content of organic chemicals below 10µg/l.

References:

DEPA (1999): "*Toxicological evaluation and limit values for methyl tert-butyl ether (MTBE), formaldehyde, glutaraldehyde and furfural.*" Environmental project no. 511.

DEPA (1999): "*Toxicological evaluation and limit values for nonylphenol, nonylphenol ethoxylates, tricresyl phosphates and benzoic acid.*" Environmental project no. 512.

DEPA (1995): "*Toksikologiske kvalitetskriterier for jord- og drikkevand*" (Toxicological quality criteria for soil and drinking water). Project no. 12.

C-values, air

C-values (contribution values) are used as emission concentration values in outdoor air in connection with airborne emissions of pollutants from industrial plants. To comply with the C-values, the emission from a plant should be lower than the C-value in 99% of the time (i.e. the C-value can maximally be exceeded 7 hours during a month).

The C-values are contribution values and do not take background levels of the pollutants into account.

The C-values are also used as air quality criteria for the evaporation of volatile soil pollutants into indoor air.

Substance:	**CAS-no.**	**C-value mg/m^3**
Acetaldehyde	75-07-0	0.02
Acetic acid	64-19-7	0.1 /L
Acetic anhydride	108-24-7	0.02
Acetone	67-64-1	0.4
Acetonitrile	75-05-8	0.1
Acetophenone	98-86-2	0.01
Acrolein	107-02-8	0.001
Acrylonitrile	107-13-1	0.002 /C
Acrylic acid	79-10-7	0.02 /L
Allyl alcohol	107-18-6	0.01
Allyl ethyl ether	557-31-3	0.001
Aluminium compounds in inorganic dust (measured as Al)	-	0.01
2-Aminoethanol	141-43-5	0.01
Ammonia, anhydrous	7664-41-7	0.3
Ammonium chloride	12125-02-9	0.08
Aniline	62-53-3	0.08
Anthracene	120-12-7	
Antimony compounds in inorganic dust (measured as Sb)	-	0.001
Antu = 1-(1-naphtyl)-2-thiourea	86-88-4	0.0001
Aromatic hydrocarbons (C_9)	-	0.03 /L
Arsenic, inorganic compounds (measured as As)	-	0.00001
Arsine	7784-42-1	0.00001
Asbestos	1332-21-4	400 /F
Aziridine	151-56-4	0.0001
Benzene	71-43-2	0.005 /C
Benzoic acid	65-85-0	0.02
Benzyl alcohol	100-51-6	0.1
Beryllium compounds in inorganic dust (measured as Be)	-	0.00001
BHC or HCH = 1,2,3,4,5,6-hexachlorocyclohexane	608-73-1	0.001

Substance:	CAS-no.	C-value mg/m^3
Bis(2-chlorethyl) ether	111-44-4	0.0001
m-Bis(2,3-epoxypropoxy)benzene	101-90-6	0.001
Bis(2-ethylhexyl)phthalate = DEHP	117-81-7	0.005
Bis(tributyltin)oxide	56-35-9	0.0005
Bromoethane	74-96-4	0.1
Bromomethane	74-83-9	0.1
1-Butanol	71-36-3	0.2
2-Butanol	78-92-2	0.7
Butanone	78-93-3	1
2-Butoxyethanol = ethyleneglycol-monobutylether = butylglycol	111-76-2	0.04 /L
2-(2-Butoxyethoxy)ethanol = butyldiglycol = diethyleneglycol-monobutylether	112-34-5	0.02 /L
2-(2-Butoxyethoxy)ethyl acetate = diethyleneglycol-monobutylether acetate	124-17-4	0.03 /L
2-Butoxyethyl acetate= Butylglycol acetate	112-07-2	0.1 /L
(2-Butoxymethylethoxy)propanol = dipropyleneclycol-n-butylether	35884-42-5	0.4
2-Butoxy-1-methylethyl acetate = Propyleneglycol-n-butylether acetate	85409-76-3	0.1
1-Butoxypropan-2-ol = 2-propyleneglycol-1-n-butylether	5131-66-8	0.4
n-Butyl acetate	123-86-4	0.1 /L
Butyl acrylate	141-32-2	0.006 /L
Butyl glycolate	7397-62-8	1
Butyl lactate	138-22-7	0.1
Butyraldehyde	123-72-8	0.001
Butyric acid	107-92-6	0.0001 /L
γ-Butyrolactone	96-48-0	0.3
Cadmium compounds. (measured as Cd)	-	0.00001
ε-Caprolactam	105-60-2	0.005
Carbon disulphide	75-15-0	0.02
Carbon monoxide	630-08-0	1
Carbontetrachlorid = T Carbon tetrachloride = tetrachloromethane	56-23-5	0.005
Chlorine	7782-50-5	0.01
Chlorobenzene	108-90-7	0.1
Chloroacetic acid	79-11-8	
1-Chloro-2,3-epoxypropane = epichlorhydrin	106-89-8	0.002
Chloroethane	75-00-3	0.1
Chloroethylene = Vinylchloride	75-01-4	0.002 /C
Chloroform = trichloromethane	67-66-3	0.02
Chloromethane	74-87-3	0.04
1-Chloro-3-nitrobenzene	121-73-3	0.0005

Substance:	CAS-no.	C-value mg/m^3
1-Chloro-4-nitrobenzene	100-00-5	0.0005
3-Chloropentane-2,4-dione	1694-29-7	0.01 /L
Chlorophenols (mono-,di-,tri-,tetra-)	-	0.0008 /C
3-Chloropropene	107-05-1	0.002
α-Chlorotoluene	100-44-7	0.0008
Chromium compounds, other than Cr (VI) in inorganic dust (measured as Cr)	-	0.001
Chromates (measured as Cr VI)	-	0.0001
Coal tar destillates Bp >200 °C		0.00003
Coal tar pitch 10%		0.000004
Coal tar pitch 3%		0.00001
Cobalt compounds in inorganic dust (measured as Co)	-	0.0005
Colecalciferol = Vitamin D3	67-97-0	0.002
Copper compounds in inorganic dust (measured as Cu)	-	0.01
Cresol	1319-77-3	0.003 /L
Cumene = isopropylbenzene	98-82-8	0.03 /L
Cyanides in inorganic dust (measured as CN)	-	0.06
Cyclohexane	110-82-7	1
Cyclohexanol	108-93-0	0.05 /L
Cyclohexanone	108-94-1	0.1
Cyclohexyldimethylamine	98-94-2	0.01
Cyclopentanone	120-92-3	0.1
Distillates (petroleum) hydrodesulfurized middle	64742-89-9	0.01
Dialkyl sulphides	-	0.001 /L
1,4-Diazabicyclooctane	280-57-9	0.1
1,2-Dibromoethane	106-93-4	0.0001 /C
Dibutylamine	111-92-2	0.01
2,6-Di-tert-butyl-p-cresol = butylhydroxytoluene	128-37-0	0.01
1,2-Dichlorobenzene	95-50-1	0.1
Dichlorodifluoromethane	75-71-8	1
1,2-Dichloroethane	107-06-2	0.004 /C
1,1-Dichloroethylene	75-35-4	0.01
1,2-Dichloroethylene	540-59-0 156-60-5 156-59-2	0.4
1,1-Dichloro-1-flouroethane = HCFC-141b	1717-00-6	1
Dichloromethane	75-09-2	0.02 /C
1,2-Dichloropropane	78-87-5	0.02 /C
Dieldrin	60-57-1	0.0001
Diesel oil	-	0.1 /L
Diethylamine	109-89-7	0.02
Diethyl ether	60-29-7	1
Diethyl sulphate	64-67-5	0.000004 /C
Dimethoxymethane	109-87-5	1
N,N-Dimethylacetamide	127-19-5	0.1

Substance:	CAS-no.	C-value mg/m^3
Dimethylamine	124-40-3	0.04
2-Dimethylaminoethanol	108-01-0	0.005 /L
[4-[[4-(Dimethylamino)phenyl][4-[ethyl(3-sulfonatobenzyl)amino] phenyl]methylene]cyclohexa-2,5-dien-1-ylidene](ethyl)(3-sulfonato-benzyl)ammonium, sodium salt = C.I. Acid Violet 49 = C.I. Food Violet 2	1694-09-3	0.001
Dimethyl ether	115-10-6	1
N,N-Dimethylformamide	68-12-2	0.1
2,6-Dimethylheptan-4-one	108-83-8	0.06 /L
Dimethylnitrosoamine	62-75-9	0.0001
Dimethyl sulphate	77-78-1	0.1×10^{-6}
Dimethyl sulphide	75-18-3	0.001 /L
Dinitrogenoxide	10024-97-2	1
1,4-Dioxane	123-91-1	0.01-0.1
Diphenyl ether	101-84-8	0.0004 /L
Dust from grinding stainless steel Dust from grinding (apart from the above mentioned)		0.001 0.01
Dust, inert below 10 micrometer	-	0.08
D-vitamin Ergocalciferol = vitamin D2 Cholecalciferol = vitamin D3	 50-14-6 67-97-0	0.002
Endotoxines	-	1×10^{-6}
Enzymes, proteolytic	-	3×10^{-6}
1,2-Epoxy-2-(epoxyethyl)cyclohexane	4223-10-3	0.001
(Epoxyethyl)benzene	96-09-3	0.001
Epoxy, dust from powder painting procedures	-	0.01
Ergocalciferol	50-14-6	0.002
Ethan-1,2-diol = Ethylene glycol	107-21-1	0.3
Ethanol	64-17-5	5
2-Ethoxyethanol = ethyleneglycol-monoethylether	110-80-5	0.2
2-(2-Ethoxyethoxy)ethanol = Diethyleneglycol-monoethylether	111-90-0	1
2-Ethoxyethyl acetate = ethyleneglycol-monoethylether acetate	111-15-9	0.1
2-Ethoxy-1-methylethyl acetate = 2-propyleneglycol-1-ethylether acetate	54839-24-6	0.01 /L
1-Ethoxypropan-2-ol = propyleneclycol-monoethylether	1569-02-4	1
Ethyl-2-cyanoacrylate	7085-85-0	0.01
Ethyl acetate	141-78-6	1 /L
Ethylbenzene	100-41-4	0.5
Ethyldimethylamine	598-56-1	0.002
Ethylene oxide	75-21-8	0.005
Ethyl formate	109-94-4	1 /L
Ethyl nitrite	109-95-5	0.1
Flour, dust	-	0.02

Substance:	CAS-no.	C-value mg/m³
Fluorides, inorganic compounds (measured as F)		0.001
Fluorine	7782-41-4	0.002
Formaldehyde	50-00-0	0.01
Formic acid	64-18-6	0.003
2-Furaldehyde	98-01-1	0.002
Gasoline	-	0.1
Glutaral	111-30-8	0.001
1-Heptanol	111-70-6	1
2-Heptanone	110-43-0	0.1 /L
Hexamethylene diisocyanate	822-06-0	0.0002
Hexamethylphosphoric triamide	680-31-9	0.001
Hexane = n-hexane	110-54-3	0.4
Hexanones	-	0.3
Hydrazine (and its salts)	302-01-2	0.0002
Hydrogen chloride	7647-01-0	0.05
Hydrogen cyanide	74-90-8	0.06
Hydrogen fluoride	7664-39-3	0.002
Hydrogen sulphide	7783-06-4	0.001
2-Hydroxyethyl-acetate = ethyleneglycol-monoacetate	542-59-6	0.1 /L
4-Hydroxy-4-methylpentan-2-one = diacetone alcohol	123-42-2	0.1
Imidazolidine-2-thione	96-45-7	0.001
2,2’-Iminodiethanol = diethanolamine	111-42-2	0.01
3-iodo-2-propynyl butylcarbamate	55406-53-6	0.1
Isobutyl acetate	110-19-0	0.3 /L
Isocyanates, organic compounds	-	0.0002
Isopentyl acetate	123-92-2	0.02 /L
Isopropyl acetate	108-21-4	0.7 /L
Isopropylamine	75-31-0	0.3
4-Isopropylbenzyl-alcohol	536-60-7	0.01 /L
Isothiocyanates	-	0.001
Lactic acid bacteria	-	0.02
Lead compounds in inorganic dust (measured as Pb)	-	0.0004
Lithium compounds in inorganic dust (measured as Li)		0.01
Magnesium compounds in inorganic dust, See “Dust, inert below 10 micrometer”		
Maleic anhydride	108-31-6	0.001
Manganese compounds in inorganic dust (measured as Mn)	-	0.001
Mercury-compound in inorganic dust (measured as Hg)	-	0.0001
Mesitylene = 1,3,5-trimethylbenzene	108-67-8	0.03
Methanol	67-56-1	0.3
3-Methylbutanone	563-80-4	0.5 /L
3-Methoxybutyl acetate	4435-53-4	0.2

Substance:	CAS-no.	C-value mg/m^3
2-Methoxyethanol = ethyleneglycol-monomethylether	109-86-4	0.02
(2-(2-Methoxymethylethoxy) methylethoxy)propanol = tripropyleneglycol-monomethylether	25498-49-1	1
(2-Methoxymethylethoxy)propanol = dipropyleneglycol-monomethylether	34590-94-8	1
2-Methoxy-1-methylethyl acetate = propyleneglycol-monomethylether actetate	108-65-6	0.01 /L
1-Methoxypropan-2-ol = propyleneglycol-monomethylether	107-98-2	0.03 /L
Methyl acetate	79-20-9	0.7 /L
Methyl acrylate	96-33-3	0.002 /L
Methylamine	74-89-5	0.07
1-Methylbutyl acetate	626-38-0	0.001 /L
Methyl tert-butyl ether = MTBE	1634-04-4	0.03 /L
Methyl carbamate	598-55-0	0.2
Methylcyclohexane	108-87-2	1
4,4'-Methylenebis[2-chloroaniline] (and its salts)	101-14-4	0.001
Methyl formate	107-31-3	0.2
5-Methylhexan-2-one = methylisoamylketone	110-12-3	0.005 /L
Methyl methacrylate	80-62-6	0.03
4 -Methylmorpholine	109-02-4	0.1
Methyloxirane = propylenoxid	75-56-9	0.003
2-Methylpentan-1-ol	105-30-6	0.05 /L
4-Methylpentan-2-one = methylisoamylketone	108-10-1	0.2
2-Methylpropan-1-ol	78-83-1	0.4
2-Methylpropan-2-ol = tert-butylalcohol	75-65-0	1
2-Methylpropen	115-11-7	0.06 /L
1-Methyl-2-pyrrolidone	872-50-4	1
Mineral oil, aerosols	-	0.003
Mineral wool		1300 /F
Molybdenum compounds in inorganic dust (measured as Mo)	-	0.005
Naphta, hydrotreated heavy	64742-48-9	1,0 /L
Naphthalene	91-20-3	0.04 /L
Nicotine	54-11-5	0.01
Nickel (measured as Ni)	7440-02-0	0.0001
Nickel monoxide (measured as Ni)	1313-99-1	0.0001
Nitric acid	7697-37-2	0.01
2,2',2''-Nitrilotriethanol	102-71-6	0.01
Nitrobenzene	98-95-3	0.0002 /C
2-Nitronaphthalene	581-89-5	0.001
Nitrophenols	-	0.005
Nonylphenol	84852-15-3	0,02
Nonylphenol ethoxylates		0.05

Substance:	CAS-no.	C-value mg/m^3
Organic solvents, mixtures (1)		0,15 /L
Orthophosphoric acid = phosphoric acid	7664-38-2	0.005
7-Oxa-3-oxiranylbicyclo(4.1.0)heptane = 1,2-epoxycyclohexane-4-oxirane	106-87-6	0.001 /C
Ozone	10028-15-6	0.01
Parafiner $C_{2\ og}$ Parafins, C2 – C8 (except n-hexane)	-	1
Pentachlorophenol	87-86-5	0.00004 /C
Pentane-2,4-dione	123-54-6	0.01 /L
Pentane-2-one	107-87-9	1
Pentane-3-one	96-22-0	0.6 /L
Pentyl acetate	628-63-7	0.02 /L
Phenol	108-95-2	0.02
2-Phenoxyethanol	122-99-6	0.1
m-Phenylenediamine	108-45-2	0.001
1-Phenyl ethanol	98-85-1	0.3
2-Phenylpropene	98-83-9	0.06
Phosgene	75-44-5	0.001
Phosphine	7803-51-2	0.001
Phthalates except DEHP	-	0.01
Phthalic anhydride	85-44-9	0.001
Pin-2(3)-ene = alpha-Pinene	80-56-8	0.05
Piperidine	110-89-4	0.01
Polyamides, dust	-	0.01
Polyaromatic hydrocarbons, PAHs	-	(2) /C
Polyurethane foam, dust	9009-54-5	0.04
Potassium hydroxide	1310-58-3	0.005
Propane-1,2-diol = Propyleneglycol	57-55-6	1
Propane-1,2-diol diacetate = Propyleneglycol-diacetate	623-84-7	1
Propanols 1-propanol 2-propanol	62309-51-7 71-23-8 67-63-0	1
Propionic acid	79-09-4	0.05
Propyl acetate	109-60-4	0.1
2-(Propyloxy)ethanol = ethyleneglycol-monopropylether	2807-30-9	0.3
Pyridine	110-86-1	0.07
2-Pyrrolidone	616-45-5	0.003
Quartz	14808-60-7	0.005
Siliciumdioxide (amorphous)	61790-53-2	0.005
Silver compounds in inorganic dust (measured as Ag)	-	0.0002
Sodium hydroxide in inorganic dust	1310-73-2	0.005
Solventnaphtha, light aromatic	64742-95-6	0.03 /L
Solventnaphta (petroleum), heavy aromatic	64742-94-5	0.05 /L
Stannane, tributyl-, mono(naphthenoyloxy) derivatives	85409-17-2	0.0005
Strontium chromate	7789-06-2	0.0001
Styrene	100-42-5	0.2

Substance:	CAS-no.	C-value mg/m^3
Subtilisin	9014-01-1	3×10^{-6}
Sulphuric acid	7664-93-9	0.01
Sulphur trioxide	7446-11-9	0.01
Soaps (Na-, K- and Ca- salts of fatty acids)	-	0.01
Tetrachloroethylene	127-18-4	0.01 /C
Tetraethyllead (measured as Pb)	78-00-2	0.0003
Tetraethyl-orthosilicate = Ethyl silicate	78-10-4	1
Tetrahydrofuran	109-99-9	0.2
3a,4,7,7a-Tetrahydro-4,7-methanoindene =dicyclopentadiene	77-73-6	0.05
Tetramethyllead (measured as Pb)	75-74-1	0.0003
Thallium compounds in inorganic dust (measured as Tl)	-	0.0003
Thiols	-	0.0002
Thioalcohols	-	0.0002
Tin compounds in inorganic dust (measured as Sn)	-	0.02
Titanium dioxide	13463-67-7 1317-70-0 1317-80-2	0.02
Toluene	108-88-3	0.4
1,1,1-Trichlorethane	71-55-6	0.5
Trichloroethylene	79-01-6	0.04 /C
Triethylamine	121-44-8	0.04
Trimethoxyvinylsilane	2768-02-7	0.001
Trimethylamine	75-50-3	0.0002
3,5,5-Trimethylcyclohex-2-enone	78-59-1	0.03
Tripropylenglycolmonoethylether	20178-34-1	1
Trypsin	9002-07-7	3×10^{-6}
Vanadium compounds in inorganic dust (measured as V)	-	0.0003
Vegetable oils, aerosols	-	0.01
Vinyl acetate	108-05-4	0.2
Waxes, primarely straight chained hydrocarbons >C20	-	0.01
Welding fumes Fumes from welding in unalloyed steel: Fumes from welding in alloyedt steel, Sum of content of nickel and chromium (VI):		 0.004 0.0001
White spirit: Naphta, hydrosulfurized heavy Stoddard-solvent Solvent naphta, medium aliphatic	 64742-82-1 8052-41-3 64742-88-7	 0.2 /L 0.2 /L 0.2 /L
Wollastonite	13983-17-0	1300 /F
Wood, dust	-	0.025
Xylene, mixed isomers, pure	1330-20-7	0.1
Xylenols	-	0.002 /L
Zinc compounds in inorganic dust, except zinc chloride (measured as Zn)	-	0.06
Zinc chloride	7646-85-7	0.005

/C: this notation is attached to specific compounds for which the cumulated exposure is considered to reflect the risk for adverse effect e.g. carcinogenic/ mutagenic compounds. The basis for the C-value is the health based air quality criteria, which for such substances reflects an average exposure level (continuous exposure). The C-value, however, is set 40 times higher than the air quality criteria, because compliance with a C-value (i.e. the actual emission concentration values should be below the C-value in 99% of the time) according to emission distribution models, represents an average exposure level in the surroundings of the emission source of about 1/40 of the C-value.

/F: fibers per m^{3}.

/L: the C-value is based on protection against odour. For substances with this notation, odour is considered to occur at considerable lower levels (<1/10) compared to a toxicological based value.

(1) Mixture of organic solvents used as thinners and solvents in paints and lacquers. The mixture must at least contain 3 or more organic solvents where none of the solvents may represent a content of more than 80 w/w % or less than 2 w/w %. None of the single solvents may be considered especially critical (e.g. be considered as a carcinogen), or appointed with a specific C-value of 0.01 mg/m^3 or lower (the latter rule pertain to health based C-values and does not include substances having an L-notation attached to the C-value).

(2) C-value for PAHs: 2,5 ng benzo(a)pyrene equivalents/ m^3 where Benzo(a)pyrene equivalents $= \Sigma\, konc_{PAH}$ x relative potency factor $_{PAH}$.

For the calculation of the benzo(a)pyrene equivalent, the following PAHs and their relative potency factors are used:

PAH	Relative potency factor
Acenaphthene	0,001
Acenapthylene	0,001
Anthracene	0,0005
Benzo[a]anthracene	0,005
Benzo[b]fluoranthene	0,1
Benzo[k]fluoranthene	0,05
Benzo[ghi]perylene	0,02
Benzo[a]pyrene	1
Chrysene	0,03
Dibenzo[a,h]anthracene	1,1
Fluoranthene	0,05
Fluorene	0,0005
Indeno[1,2,3-c])pyrene	0,1
Phenanthrene	0,0005
Pyrene	0,001

Table of provisional C-values. Notified for future incorporation in the main table.

Substance:	CAS-No.:	C-value mg/^{m3}
Acrylamide	79-06-1	0.0002 /C
3-aminomethyl-3,5,5-trimethylcyclohexylamine = isophoronediamine	2855-13-2	0.01
Barium, inorganic compounds		0.005
Bis(2-(dimethylamino)ethyl)ether	3033-62-3	0.01
Boron		0.003
1-bromopropane	106-94-5	0.1
Butane-1,4-diol	110-63-4	0.1
Decahydronaphthalene = decalin	91-17-8	0.01
Dichlorodiflouromethane	75-71-8	1
Diethyl carbonate	105-58-8	0.1
N-[3-(dimethylamino)propyl]-N,N',N'-trimethylpropane-1,3-diamine	3855-32-1	0.01
Dipropylenglycol = oxydipropanol		1
Dipropylenglycoldimethylether = oxydipropanol dimethylether	111109-77-4	1
Epoxy compounds, monomers		0.001
2,3-epoxypropyltrimethylammonium chloride = GMAC	3033-77-0	<0.001
Ethyl bromide	74-94-4	0.1
Formamide	75-12-7	0.01
Methyl iodide	74-88-4	0.001
2-methylstyrene = 2-vinyltoluene	611-15-4	0.1
Naphta (petroleum), hydrodesulfurized light, dearomatized (mainly heptanes)	92045-53-9	1
Solvent Naphta (petroleum), light, aliphatic.	64742-89-8	1
Nitroethane	79-24-3	0.01
2-phenylpropan-2-ol = 1-hydroxycumen	617-94-7	0.01
Polyester, dust from spray-painting		0.01
Propylbenzene	103-65-1	0.03
Silicon dioxide	63231-67-4	0.005
Talc, inorganic dust	14807-96-6	0.001
1,1,1,2-tetrafluoroethane = HFC 134a	811-97-2	1
Trichlorofluoromethane = CFC 11	75-69-4	1

2,4,6-tinitrotoluene	118-96-7	0.001

Reference:

DEPA (2000): "*B-værdier. Vejledning nr. 15, Udkast*". (C-values, Guideline no. 15, Draft).

Overview of economic instruments in Denmark (taxes, fees, etc.)[1]

Name and Type of Instrument	Purpose	Tax base	Tax rates 1999	Environmental media	Economic sector
Product tax/charge					
Energy taxes	Fiscal and environmental		In total 43-63 DKK/GJ for fossil fuels. 0-2 DKK/GJ on renewables.	Climate	Transport, households
Motor vehicles	Fiscal and environmental	One time registration plus annual vehicle tax	About 65% of the consumer price for an average car are taxes (import price DKK 80,000, consumer price DKK 230,000)	Air	Transport, households
Vehicle fuels	Fiscal, fuel import control, environmental	Tax/litre of the various types of fuels (quantity)	About 50% of the consumer price of petrol. (DKK 3.8 of a final consumer price of DKK 7)	Air, climate	Transport, households
Tap water	Environmental	Tax/m^3 water	In 1998 about 5 DDK/m^3, consumers only.	Surface and ground water	Manufacturing, households
Retail containers	Environmental	Tax/kilo (weight) and tax/litre (volume)	Different tax types and systems.	Soil and ground water	Households
Disposable tableware	Environmental	Tax per value of products	33% of the whole sale price, corresponding to 50% of the price exclusive of VAT.	Soil and ground water	Households
CFC tax	Environmental	Tax/kilo (weight)	30 DDK/kilo	Air	Manufacturing
Chlorinated solvents	Environmental	Tax/kilo (weight)	2 DKK/kilo, corresponding to about a 25% increase in the consumer price.	Air	Manufacturing

[1] Report: Economic Instruments in Environmental Protection in Denmark, the Danish Energy Agency, 1999.

Name and Type of Instrument	Purpose	Tax base	Tax rates 1999	Environmental media	Economic sector
PVC	Environmental	Tax/kilo (weight)	3,50 DKK/kilo	Air, soil, waste, wastewater	Manufacturing
Pesticides	Environmental	Tax/retail price of the various types of pesticides	Agricultural pesticides: 33.33% on the retail price exclusive of taxes. Insecticides: 53.85% of the retail price, exclusive of taxes. Other biocides and microbiological plant protection products: 3.1% of the retail price, exclusive of taxes	Soil and groundwater	Agriculture
Growth promoters	Animal well-being	Tax/gram (weight)	The tax implies that production costs per porker or piglet will increase about 4 DKK.	Soil and groundwater	Agriculture
Lead Accumulators	Environmental	Fee/accumulator	DKK 12-24, refund DKK 0,8/kg	Soil and groundwater	Households and industry
NiCd batteries	Environmental	Tax/battery	The tax is 6 DKK/battery, and the refund is 150 DKK/kilo returned batteries.	Soil and groundwater	Households
Effluent tax/charge					
CO_2	Environmental	Tax/emitted CO_2	100 DKK/ton emitted CO_2. It is differentiated to ensure that all energy types become liable to a tax that corresponds to this level.	Air	Agriculture, energy, manufacturing, households
SO_2	Environmental	Tax/sulphur content in fuels or tax/kilo sulphur emitted	Different options.	Air	Agriculture, energy, manufacturing, households
Waste and raw materials	Environmental	Tax/kilo of various types of waste and raw materials.	Raw materials: 5 DKK/m^3. Waste for landfills: DKK 375/tons. Waste for incineration: 280-330 DKK/tons.	Soil and ground water	Manufacturing, households

Name and Type of Instrument	Purpose	Tax base	Tax rates 1999	Environmental media	Economic sector
Sewage tax	Environmental	Tax/kilo of various types of substances	The tax rates for the substances nitrogen, phosphorus, and organic substances are DKK/kg: 20, 110, and 11 respectively.	Water	Manufacturing, households
User fees					
Water supply and sewage	Cost-recovery, environmental	Connection fee, administrative fee, and a tap water fee	Connection fees amount to DKK 30,000 and 50,000 for sewage and water respectively. Average annual fees of 11.5 and 4 DKK/m3 for sewage and water respectively.	Water	Manufacturing, households
Waste	Cost-recovery, environmental	Fee/household fee and a tap water fee	Average hazardous waste user fee is DKK 2,500 per tons.	Soil and groundwater	Manufacturing, households
Road toll	Cost recovery	Tax/truck (various types of trucks)	Heavy-duty vehicles: DKK 5.5 and DKK 9.2.		Transport
Deposit refund					
Bottles	Environmental	Deposit/bottle	DKK/container: 1.25 – 4, depending on i.e. the size of the container.	Soil and ground water	Households

EU ambient air quality limit values

The following table summarises the EU ambient air quality limit values for the protection of human health. Limit values for the protection of ecosystems and agriculture are omitted.

Pollutant	Average time	EU limit values μg/m^3	Conditions of EU limit value
Sulphur dioxide (SO_2)	10 minutes		No EU threshold but measuring and reporting required at selected stations.
	1 hour	350	Not to be exceeded more than 24 times per calendar year (99.7 percentile). 43% margin of tolerance allowed in 2000, lowering in annual steps until 2005 when full compliance is required.
	24 hours	125	Not to be exceeded more than 3 times per calendar year (99.2 percentile)
Nitrogen dioxide (NO_2)	1 hour	200	Not to be exceeded more than 18 times per calendar year (99.8 percentile). 50% margin of tolerance allowed in 2000, lowering in annual steps until 2010 when full compliance is required.
	1 year	40	50% margin of tolerance allowed in 2000, lowering in annual steps until 2010 when full compliance is required.
PM_{10}	24 hours	50	Not to be exceeded more than 35 times per calendar year (90.4 percentile, 2005), decreasing to 7 times per calendar year (98 percentile, 2010). 50% margin of tolerance allowed in 2000, lowering in annual steps until 2005.
	1 year	40 (2005) 20 (2010)	50% margin of tolerance allowed in 2000, lowering in annual steps until 2010.
$PM_{2.5}$	24 hours		No EU threshold but measuring and reporting required at representative locations. [Proposed USA limit value: 65 μg/m^3.]
	1 year		No EU threshold. [Proposed USA limit value: 15 μg/m^3.]
Lead (Pb)	1 year	0.5	100% margin of tolerance allowed in 2000, lowering in annual steps until 2005.

Pollutant	Average time	EU limit values µg/m^3	Conditions of EU limit value
Ozone (O_3)	8 hour average	110	Existing EU threshold (1992) for reporting purposes. Calculated as non-overlapping 8-hour averages.
	8 hour average, highest each day	120	Proposed: Not to be exceeded by more than 20 days per calendar year averaged over 3 years (94.5 percentile). Long-term objective: highest 8-hour average within a calendar year.
Carbon monoxide (CO)	8 hours	10,000	Proposed: 50% margin of tolerance allowed in 2000, lowering in annual steps until 2005 when full compliance is required.
Benzene	1 year	5	Proposed: 100% margin of tolerance allowed until 1 Jan 2003, lowering in annual steps until 1 Jan 2010 when full compliance is required.

Quality requirements to drinking water

Main components in drinking water

Parameter	Unit	Value at point of distribution input at waterworks[1]	Value in service connection at building[2]	Comments
Colour[3]	mg Pt/l	5	15	
Turbidity[3]	FTU	0.3	0.5	
Smell Taste	Subjective evaluation			The water must not have an abnormal taste or smell.
Temperature	°C			It should be ensured that the water has a maximum temperature of 12° at the water tap.
pH		7.5 - 8.5		The water must not be aggressive.
Conductivity	mS/m	> 30		
NVOC	mg C/l	4		
Total residue[3]	mg/l	1,500		
Calcium	mg Ca/l			The content should not exceed 200 mg/l.
Magnesium	mg Mg/l	50		
Hardness, total	°dH			The hardness of the water should be between 5 and 30° H.
Sodium	mg Na/l	175		
Potassium	mg K/l	10		
Ammonium	mg NH_4/l	0.05[4]		
Iron	mg Fe/l	0.15[5]	0.2	
Manganese	mg Mn/l	0.02[5]	0.05	
Bicarbonate	mg HCO_3/l			The content should be above 100 mg/l.
Chloride	mg Cl/l	250		
Sulfat sulphate	mg SO_4/l	250		
Nitrate	mg NO_3/l	50		
Nitrite	mg NO_2/l	<0.01	0.1	The content should be less than 0.5 mg/l when appplying chloramine.
Total content of phosphorus[3]	mg P/l	0.15		
Fluorid	mg F/l	1.5		
Oxygen	mg O_2/l		5	
Aggressive carbon	mg CO_2/l	< 2		

Parameter	Unit	Value at point of distribution input at waterworks[1]	Value in service connection at building[2]	Comments
dioxide[3]				
Hydrogen sulphide[3]	mg H_2S/l	< 0.05		
Methane[3]	mg CH_4/l	< 0.01		
Chlorine, free and total[3,6]	mg Cl/l			The content should be as low as possible and comply with microbiological requirements.

1) The sample shall be taken at the point of distribution input, alternatively from the clean water tank at the waterworks.
2) The sample shall be taken at the entrance to the building (at the water meter or the nearest water tap hereafter) only when the water has been running for minimum 5 minutes to ensure flushing of installations and the service connection.
3) The investigations shall be made according to a method assigned by the Danish Environmental Protection Agency.
4) In order to avoid nitrite in the line system, the content in oxidized and filtered water should be < 0.05 mg/l. A content of ammonium exceeding 0.5 mg/l may be accepted, and the content of ammonium is not converted into nitrite in the line system for unfiltered drinking water.
5) Deviations as a result of renewal of filter materials may occur, but should be reduced to a minimum.
6) Or the remains of another disinfectant.

Microbiological parameters[1]

Parameter	Unit	Value at point of distribution input at waterworks[1]	Value in service connection at building[2]	Comments
Coliform bacteria	per 100 ml	n.d.	n.d.	
Escherichia coli (E. coli)	per 100 ml	n.d.	n.d.	
Colony Count at 37° C	per ml	10	30	New analytical method applied in 2001.
Colony Count at 22° C	per ml	70	250	New analytical method applied in 2001.
Enterococci	per 100 ml	n.d.	n.d.	
Clostridium perfringens, including spores[3])	per 50 ml	n.d.	n.d.	

1) The tests are made according to a method assigned by the Danish Environmental Protection Agency.
2) The sample shall be taken at the entrance to the building (at the water meter or the nearest water tap hereafter) only when the water has been running for minimum 5 minutes to ensure flushing of installations and the service connection.
3) The parameter is measured only if the water originates from or is influenced by surface water.

n.d. = not detected by the assigned method.

Inorganic tracers

Parameter	Unit	Value at point of distribution input at waterworks[1]	Value in service connection at building[2]	Comments
Metals				
Aluminium	µg Al/l	100	200	
Antimony	µg Sb/l	2	5	
Arsenic	µg As/l	5	10	
Barium	µg Ba/l	700	700	
Lead	µg Pb/l	5	10 15	Calculated as an average value[3] After 12 hours residence time in the consumer's installation.
Boron	µg B/l	1000[4]	1000	
Cadmium	µg Cd/l	2	5	
Chromium, total	µg Cr/l	20	50	
Cyanide	µg CN/l	50	50	
Copper	µg Cu/l	100	2000 2000	Calculated as an average value[3] After 12 hours residence time in the consumer's installation.
Mercury[5]	µg Hg/l	1	1	
Nickel	µg Ni/l	10	20	
Selenium	µg Se/l	10	10	
Silver[6])	µg Ag/l	10	10	
Tin	µg Sn/l	10	1500	After 12 hours residence time in the consumer's installation.
Zinc	µg Zn/l	100	3000 5000	Calculated as an average value[3]) After 12 hours residence time in the consumer's installation.
Halogenous transformation products				
Sum of chlorite and chlorate[7]	µg Cl/l	30	30	
Bromate[8]	µg BrO_3/l	10	10	
Radioactivity indicators				
Tritium[9]	Bq/l	100		
Total indicative dose [9,10]	mSv/year	0.1		

1) The sample shall be taken at the entrance to the building (at the water meter or the nearest water tap hereafter) only when the water has been running for minimum 5 minutes to ensure flushing of installations and the service connection. If the water works can document that there has been no addition of metals in the distribution system, the test can be made at the point of distribution input at the water works instead.
2) The water shall be taken from the consumers water tap, after the water has been stagnant in the installations for 12 hours or by another method as assigned by the Danish Environmental Protection Agency.
3) The average value is calculated according to a method assigned by the Danish Environmental Protection Agency.
4) Drinking water should have the lowest content of boron possible and preferably below 300µg/l.
5) Drinking water should have the lowest content of mercury possible and preferably below 0,1 µg/l.
6) Only to be analysed if silver is used as a material or a chemical.
7) The decomposition products are present in the purchased 15% sodium hypochlorite solvent and will increase in concentration in stagnant water at the water works. The decomposition products can also result from a conversion of chloride in the distribution system and if chlorine dioxide is used for disinfection.
8) Is only examined when disinfection is done with chloride, ozone and similar strong oxidizing substances.
9) The measurement is made at selected stations on a national scale.
10) The measurement of the total indicative dose shall be carried out according to specifications from the Danish Environmental Protection Agency.

Organic micro-pollutants

Parameter	Value at point of distribution outlet at waterworks[1]	Value in service connection at building[2]	Comments
Chlorinated organic solvents			
Volatile organochlorine compounds[3]	1	1	The value is for each substance.
Sum of volatile organochlorine compounds[3]	3	3	The total value can only be used if the concentration of each substance is below 1 µg/l.
Vinyl chloride	0.3	0,5	
Chlorobenzenes, (mono, di and tri)	1	1	The value is for each substance.
Sum of trihalomethanes[4]	25	25	The chlorination should be carried out so the content is as low as possible.
Content in oil products			
$C_9 + C_{10}$ aromatics[5]	1	1	Indicators are sum of the following substances: 1-methyl-3-ethylbenzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene.
Benzene[5]	1	1	
Naphthalene[5,6]	2	2	
Methyl tertiary butyl ether MTBE[5]			The substance is a constituent of modern petrol products.
1,2 dibromoethane[5]	0.01[7]	0.01[7]	The substance was a constituent of former leaded petrol products.
Total petroleum hydrocarbons)[5]	5	10	
PAH compounds[6]			
Flouranthene	0.1	0.1	
Benzo (a) pyrene	0.01	0.01	
Sum of benzo (b) fluoranthene, benzo (k) flouranthene, benzo (ghi)perylene and indeno (1,2,3-cd)pyrene	0.1	0.1	
Pesticides[8]			
Aldrin, dieldrin, heptachlor, heptachlorepoxide	0.03	0.03	The value is for each substance
Other pesticides	0.1	0.1	The value is for each substance
Sum of all pesticides	0.5	0.5	
Phenols			
Phenol	0.5	0.5	
2-methylphenol[6]	0.5	0.5	
3-methylphenol[6]	0.5	0.5	
2.3-di-methylphenol	0.5	0.5	
2.4-di-methylphenol	0.5	0.5	

Parameter	Value at point of distribution outlet at waterworks[1]	Value in service connection at building[2]	Comments
2.5-di-methylphenol	0.5	0.5	
2.6-di-methylphenol	0.5	0.5	
Sum of octylphenol and nonylphenol	20	20	
Chlorophenols			
2-Chlorophenol	0.1	0.1	
4-Chlorophenol	0.1	0.1	
2,4-Dichlorophenol	0.1	0.1	
2,6-Dichlorophenol	0.1	0.1	
2,4,6-Trichlorophenol	0.1	0.1	
Pentachlorophenol	0.01[9]	0.01[9]	
4-Chloro-2-methylphenol	0.1	0.1	
6-Chloro-2-methylphenol	0.1	0.1	
4,6-Dichloro-2-methylphenol	0.1	0.1	
Phthalate			
Di-ethyl-hexyl-phthalates (DEHP)	1	1	
Sum of other phthalates	1	5	
Detergents			
Anionic detergents	100	100	
Monomers from polymer materials			
Acrylamide	0.1	0.1	Use of chemicals with content of this substance should not be used for water treatment.
Acrylonitrile	0.05	0.1	
Epichlorhydrin[10]	0.1	0.1	
Formaldehyde	10	50	
Styrene	0.2	1	
Vinyl chloride	0,3	0,5	

1. The sample shall be taken at the entrance to the building (at the water meter or the nearest water tap hereafter) only when the water has been running for minimum 5 minutes to ensure flushing of installations and the service connection.
2. The water shall be taken from the consumers water tap, after the water has been stagnant in the installations for 12 hours or by another method as assigned by the Danish Environmental Protection Agency.
3. Volatile organochlorine compounds are di- and trichlormethane, dichlorbrometene, chlordibrommethane and tribromethane, tetrachlortene and tetrachlorethane.
4. Trihalomethane are the sum of the content of trichlormethan, dichlorbrommethan, clordibrommethan and tribrommethan, made by chlorination og the natural content og organic matters in water.
5. Indicators for oil- and benzen products.
6. Indicators for tar products.
7. The limit value cannot be measured by a method normally used in the laboratory. There must, until better techniques has been developed, be used a method with a detection limit of max. 0,005µg/l.
8. Pesticides are organic insecticides, herbicides, fungicides, nematocider, acaricides, algicides, rodenticides and slimicides as well as similar products (for example growth regulators) and their metabolits.
9. This limit value cannot be measures well enough with the method normally used in the laboratory. Until better techniques has been developed a method with a detection limit of max. 0,01 µg/l.
10. The parameter values refer to the content of monomers in water according to the specification for maximum migration from similar polymer products in contact with the drinking water.

Classification of substances and preparations

Classification of substances

The criteria for classifying chemical substances are based on results from laboratory tests specified in the regulations. Practical experience is also taken into consideration if this information shows that the properties and the potential hazard to man differ from what is observed in the tests. Information may derive from epidemiological studies of human exposure to chemicals, workplace exposures or reported accidents. Deliberate testing of humans with the purpose of classifying a substance is not allowed. The test results and general experience are used to determine:

- the type of danger, as expressed through the danger categories
- the degree of danger, i.e. how pronounced the related effects are (e.g. if the substance should be classified as very toxic, toxic or harmful by ingestion)
- the certainty of the effect (or strength of evidence) in relation to chronic toxicity, carcinogenicity, mutagenicity and reproductive toxicity as these properties can be difficult to demonstrate with absolute certainty. If a substance is a known carcinogen in humans or very likely to cause cancer in humans, it is labelled *toxic* and assigned one of the following the risk phrases: *R45 (May cause cancer)* or *R49 (May cause cancer by inhalation)*. If there is more limited evidence, but still a reason to suspect a possible carcinogenic effect in humans based on relevant animal studies, the substance is labelled as harmful and assigned the risk phrase *R40 (Possible risk of irreversible effect).*

Annex I to the *substance directive* includes a list of chemical substances and groups of substances for which the classification has been agreed by the Commission. These classifications must be followed in the EU countries. The annexes to the directive, including Annex I, are regularly adapted to technical progress as a result of increased scientific knowledge and more substances are added. With the 26th adaptation, the list now includes approximately 5,000 substances and substance groups.

Substances which are not included in the list must be evaluated against the criteria specified in the directive and classified accordingly. These criteria are briefly outlined in Table 1.

Table 1 Criteria for classification of substances based on toxicological properties

Category of danger	Symbol letter	Indication of danger	Criteria for classification
Very toxic	Tx	Very toxic	*Acute toxicity* *Oral*: $LD_{50} \leq 25$ mg/kg or <100% survival at 5 mg/kg *Dermal*: $LD_{50} \leq 25$ mg/kg *Inhalation*: $LC_{50} \leq 0.25$ mg/L/4h, (aerosols and particles) $LC_{50} \leq 0.5$ mg/L/4h (gasses and vapours) *Non-lethal irreversible effects after a single exposure* Irreversible effects on e.g. liver or kidney. No specific test method. Experience from short-term tests can be used following the same dose intervals as shown above.
Toxic	T	Toxic	*Acute toxicity* *Oral*: 25 mg/kg < $LD_{50} \leq$ 200 mg/kg or critical dose 5 mg/kg *Dermal*: 50 mg/kg < $LD_{50} \leq$ 400 mg/kg *Inhalation*: 0.25 mg/kg < $LC_{50} \leq$ 1 mg/L/4h, (aerosols and particles) 0.5 mg/kg < $LC_{50} \leq$ 2 mg/L/4h (gasses and vapours) *Non-lethal irreversible effects after a single exposure* Irreversible effects on e.g. liver or kidney. No specific test method. Experience from short-term tests can be used following the same dose intervals as shown above. *Severe effects after repeated or prolonged exposure* Functional disturbances or morphological changes seen in subacute (28 days) or subchronic (90 days) animal tests. Dose levels 10 times lower than for acute toxicity (shown above).

Category of danger	Symbol letter	Indication of danger	Criteria for classification
Harmful	Xn	Harmful	<u>*Acute toxicity*</u> *Oral*: 200 mg/kg < LD_{50} ≤ 2000 mg/kg or < 100% survival at 500 mg/kg or critical dose 500 mg/kg *Dermal*: 400 mg/kg < LD_{50} ≤ 2000 mg/kg *Inhalation*: 1 mg/kg < LC_{50} ≤ 5 mg/L/4h, (aerosols and particles) 2 mg/kg < LC_{50} ≤ 20 mg/L/4h (gasses and vapours) Liquid substances, which because of low viscosity, may cause ***aspiration*** into the lungs with the risk of chemical pneumonitis when swallowed. <u>*Non-lethal irreversible effects after a single exposure*</u> Irreversible effects on e.g. liver or kidney. No specific test method. Experience from short-term tests can be used following the same dose intervals as shown above. <u>*Severe effects after repeated or prolonged exposure*</u> Functional disturbances or morphological changes seen in subacute (28 days) or subchronic (90 days) animal tests. Dose levels 10 times lower than for acute toxicity (shown above).
Corrosive	C	Corrosive	Substances, which cause destruction of skin tissue in undamaged animal skin in the skin irritation test, or can be predicted to cause this effect (e.g. because of pH ≤ 2 or pH ≥ 11.5).
Irritant	Xi	Irritant	Non-corrosive substances which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation. Various criteria exist for skin, eye and respiratory irritation.
Sensitising with R42[1] with R43[1]	 Xn Xi	 Harmful Irritant	*Inhalation*: Available documentation of specific sensitisation. Positive results from animal experiments. The substance is an isocyanate, unless it can be documented that the substance is not sensitising. *Dermal*: Practical experience showing that the substance causes sensitisation in a large number of persons. Positive results from animal experiments.
Carcinogenic Carc 1 and Carc 2: Carc 3:	 T Xn	 Toxic Harmful	*Carc 1*: Available documentation proving the correlation between exposure and development of cancer in humans, i.e. results from epidemiological studies.

Category of danger	Symbol letter	Indication of danger	Criteria for classification
			Carc 2: Documentation from animal studies in two different species or one species including information on mutagenicity, toxico-kinetics, etc. *Carc 3:* Suspected carcinogenic potential, but inadequate documentation from animal studies. Available information not sufficient to classify as Carc 2.
Mutagenic Mut 1 and Mut 2: Mut 3:	 T Xn	 Toxic Harmful	*Mut 1*: Available documentation proving the correlation between exposure and hereditary damage to genetic material in humans i.e. results from epidemiological studies. *Mut 2:* Mutagen effect in germ cells from mammals in vivo.Other cellular effects i mammal germ cells in vivo, which may be caused by mutagenicity. Mutagen effect in somatic cells in vivo and evidence that the substance or a relevant metabolite reaches the germ cells. *Mut 3:* Mutagen effect or other cellular effects in vivo in somatic cells preferably supplemented with evidence from positive in vitro studies.
Toxic to reproduction Rep 1 and Rep 2: Rep 3:	 T Xn	 Toxic Harmful	*Rep 1* *Fertility* Available documentation proving the correlation between exposure and reduced fertility in humans, i.e. results from epidemiological studies investigating sexual behaviour, spermatogenesis, agonises, hormonal activity, reproduction *Embryotoxicity* Positive documentation from epidemiological studies in humans. *Rep 2:* *Fertility* Positive results from animal studies in at least one species and additional information about mechanism of action supporting the relevance for humans. *Embryotoxicity* Positive results from animal experiments in one or more species, showing adverse effects on the offspring at dose levels without effects on the mother animal, or specific adverse effects on the offspring which are not secondary effects of toxic effects on the mother animal.

Category of danger	Symbol letter	Indication of danger	Criteria for classification
			Rep 3: *Fertility* Suspected reprotoxic potential, but inadequate documentation from animal studies. Available information not sufficient to classify as Rep 2. *Embryotoxicity* Information from inadequate animal experiments, e.g. where dose levels or toxico-kinetic differences between the animal and humans make predictions of human effects less certain

Classification of preparations
Preparations are classified in the same categories of danger as substances. Classification based on toxicological effects can follow two different approaches:

1. either the *conventional* method using concentration limits,
2. or the same methods and criteria as used for classification of substances.

When both methods have been applied, results from 2) shall be used except in the case of carcinogenic, mutagenic and reprotoxic effects.

The conventional method rests on the principle that the toxicological properties of a product can be derived from the health hazardous properties and the concentration of the individual substances in the preparation. Another important principle is the assumption that a product must contain a certain amount of a hazardous substance before the product itself is hazardous - the so-called concentration limits.

General concentration limits are assigned to the different danger categories. The concentration limits depend on the severity of the effect. For some substances, which have been shown to exhibit hazardous effects in lower concentrations than the general concentration limit, individual concentration limits are assigned. These limits appear in the list of dangerous substances. As an example the general concentration limits for preparations containing only one classified substance with acute lethal effects are shown below.

<table>
<tr><th>Classification of the substance[1] / Concentration of the substance in the preparation (w/w%)</th><th>Tx with R26, R27 and/or R28</th><th>T with R23, R24 and/or R25</th><th>Xn with R20, R21 and/or R22</th></tr>
<tr><td>0 % < conc. < 0.1 %</td><td></td><td rowspan="3"></td><td rowspan="5"></td></tr>
<tr><td>0.1 % ≤ conc. < 1 %</td><td>Xn with R20, R21 and/or R22</td></tr>
<tr><td>1 % ≤ conc. < 3 %</td><td rowspan="2">T with R23, R24 and/or R25</td></tr>
<tr><td>3 % ≤ conc. < 7 %</td><td rowspan="2">Xn with R20, R21 and/or R22</td></tr>
<tr><td>7 % ≤ conc. < 25 %</td><td rowspan="2">Tx with R26, R27 and/or R28</td></tr>
<tr><td>25 % ≤ conc.</td><td>T with R23, R24 and/or R25</td><td>Xn with R20, R21 and/or R22</td></tr>
</table>

If preparations contain more chemical substances with the same effect, the concentrations of each of these substances are added in certain situations, and the sum is used for the final classification. Evaluated effects are based on addition:

- acute toxic effects
- corrosive effects
- irritant effects

When adding the acute lethal effects, *very toxic* and *toxic* substances in individual concentrations below the concentration limits for classifying the preparation as *very toxic* or *toxic*, are added to the *harmful* substances. The following calculation should be done in this case:

$$\sum\left(\frac{P_{Tx}}{L_{Xn}}+\frac{P_{T}}{L_{Xn}}+\frac{P_{Xn}}{L_{Xn}}\right)\geq 1 \text{; where}$$

P_{Tx} is the percentage by weight of each *very toxic* substance in the preparation
P_T is the percentage by weight of each *toxic* substance in the preparation
P_{Xn} is the percentage by weight of each *harmful* substance in the preparation
L_{Xn} is the limit specified for each *very toxic*, *toxic* or *harmful* substance expressed as a percentage

Likewise, the corrive substances below the concentration limit are added to the irritant substances. Every contribution is divided by the corresponding concentration limit related to the specific category of danger and risk phrase.

[1] R26: *Very toxic by inhalation*; R27: *Very toxic in contact with skin*; R28*: Very toxic if swallowed*; R23: *Toxic by inhalation*; R24: *Toxic in contact with skin*; R25*: Toxic if swallowed*; R20: *Harmful by inhalation*; R21: *Harmful in contact with skin*; R22*: Harmful if swallowed*.

Effects which are evaluated individually:

- sensitising effects
- non-lethal irreversible effects after a single exposure
- severe effects after repeated or prolonged exposure
- carcinogenic effects
- mutagenic effects
- effects toxic to reproduction

When using the conventional method, it is important also to evaluate the product as a whole, as some constituents may inactivate each other (acid and base), polymerise or react in other ways. Synergistic and antagonistic effects should also be considered. As an example, some detergents can enhance the irritant effect on eyes of other substances and chelating substances can bind heavy metals and counteract the health hazardous effects of the metal.

Where more than one danger symbol expressing the health hazards are assigned to the preparation, only the symbol expressing the highest degree of danger should be applied.

Main EU Directives on chemicals

Directive	Title	Article	Area of regulation
Directives on classification and labelling			
67/548/EEC	Council Directive on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.	100A (95)	Basic directive regulating dangerous substances in EU: • criteria for classification and labelling • procedure for notification of new substances • risk assessment of new substances • Annex I contains the list of dangerous substances
88379/EEC (replaced by 1999/45/EC)	Council Directive on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous preparations	100A (95)	Directive regulating: • criteria for classification and labelling of preparations • provisions for classification and labelling of plant protection products • provisions for safety data sheets
Directives on regulation of marketing and use of chemicals			
76/769/EEC	Council Directive on the approximation of laws, regulations and administrative provisions relating to the restrictions on the marketing and use of certain dangerous substances and preparations.	100 (95)	Directive restricting or banning the marketing and use of e.g.: • PCP, CMR-substances to the general public, certain chlorinated substances, creosote, PCB/PCT, benzene in toys, nickel in certain objects getting into direct contact with skin, certain asbestos fibres, and flammable/extremely flammable substances in aerosol containers.
76/768/EEC	Council Directive on the approximation of the laws relating to cosmetic products.	100A (95)	Directive relating to the marketing, including labelling and use of cosmetic products. The Directive includes: • lists of banned substances and products • lists of allowed substances for colouring, preservation and sun protection including restrictions • limit values • labelling requirements • information duty

79/117/EEC	Council Directive prohibiting the placing on the market and use of plant protection products containing certain active substances.	100 (94)	Directive prohibiting the marketing and use of certain active substances in plant pretection products e.g. • alkyl/aryl-mercury compounds • persistant organic chemicals like aldrin, dieldrin and heptachlor
91/414/EEC	Council Directive concerning the placing of plant protection products on the market.	43 (37)	Directive relating to harmonised procedures for authorising plant protection products and active substances contained herein: • includes a list of approved substances • application requirements
98/8/EC	Directive of the European Parliament and of the Council concerning the placing of biocidal products on the market.	100A (95)	Directing relating to harmonised procedures for marketing of biocidal products: • approval procedure • simplified procedure for low risk substances • new active substances not on the market per 14 May 2000)
88/378/EEC	Council Directive on the approximation of the laws concerning the safety of toys.	"New method"	Directive containing minimum requirements for e.g.: • flammability and explosiveness • content of chemicals in toys
Regulations			
2455/92	Council Regulation (EEC) concerning the export and import of certain dangerous chemicals		Binding procedure relating to export and import of dangerous substances: • *Prior Informed Concent* (PIC-procedure) – obligation to notify the receiving country • substances regulated in EU • classification and labelling • based on voluntary international agreement administered by FAO[1] and UNEP[1]
793/93	Council Regulation (EEC) on the evaluation and control of the risks of existing substances.	100A (95)	Regulation aiming at carrying through systematic risk assessment of existing substances (corresponding to the 7th amendment to 67/548/EEC): • substances on EINECS • production/import > 10 tons/year • priority lists of chemicals • responsibility distributed among the Member States

Objectives and health aspects of specific waste fractions

Waste Category	Defined as hazardous waste	National objectives in 2004	Environmental problem / Health aspects	Source
Health-Care risk waste	Yes	All health-care risk waste is incinerated at incineration plants that have been specially designed and approved to treat this waste. Plants incinerating health-care risk waste are required to meet the same emission limits and operation standards as incineration plants for municipal solid waste, and the same regulations apply for disposal of residual waste.	Infectious	Hospitals, clinics, primary and secondary health sector
PCB and PCT	Yes	Total substitutions of PCB and PCT	Mutagenic, carcinogenic, highly toxic, bioaccumulative in fat issues.	Condensators and transformers
Waste oil	Yes	Environmentally safe management	Hazardous waste fractions unevenly through out the country	Garages, transport companies and households
PVC	No	No PVC waste at incineration plants Substitute certain PVC products with alternative products Phase out additives harmful to human health and environment (E.g.: lead and phthalates) Develop technologies for final treatment	PVC contains a number of environmental contaminants causing environmental problems in waste management. Incineration of PVC at waste incineration plants entails larger amounts of flue gas cleaning waste for landfilling than amounts of waste fed.	Enterprises, Construction and demolition sites and households
Impregnated wood	Partly	Utilise energy and raw material resources in waste impregnated wood.	Contains a number of environmental contaminants, which cause problems at disposal. The amount is increasing.	Construction and demolition sites and households

Waste Category	Defined as hazardous waste	National objectives in 2004	Environmental problem / Health aspects	Source
Batteries and accumulators	Partly	Recover raw material resources in all batteries 99.9 % of collection of lead accumulators 95 % collection of Ni-Cd batteries In 1998, the collection rate for NiCd batteries and lead accumulators in Denmark was 98% and 80% respectively. The objective is to reduce the amount of the heavy metals that are landfilled or incinerated. When appropriate systems for sorting and collection of batteries have been set up, all types of batteries shall be collected in Denmark. Today, the principle is that all batteries shall be collected as the consumers are not able to distinguish between the different categories.	May contain large quantities of heavy metals, especially lead but also mercury, cadmium and nickel. Non-collected ni-cd batteries are the most significant source of cadmium in waste streams. Mercury is the largest barrier to efficient treatment of batteries. Some batteries also contain resources such as steel , zinc, manganese and carbon that may be recovered.	Enterprises and households
Waste electrical and electronic equipment	Specific fractions of discarded EEE	Increased recycling of resources from waste electrical and electronic equipment Avoid delivery to waste incineration plants and landfills Environmentally safe disposal of waste electrical and electronic equipment	Waste electrical and electronic equipment contains many environmentally harmful substances, especially heavy metals. For example, 60 % of copper and 40 % of lead going to landfills and incineration plants is thought to derive from WEEE.	Enterprises and households. Electrical and electronic equipment primarily includes radio and television equipment, IT products, regulation and monitoring equipment, white goods, and office equipment.

Waste Category	Defined as hazardous waste	National objectives in 2004	Environmental problem / Health aspects	Source
Refrigeration equipment	No	90 % collection of total number of discarded products. Refrigeration equipment shall be managed so that environmental contaminants are treated separately and recyclable fractions (iron and metal parts) are recovered.	Refrigeration equipment contains CFCs (chlorofluorocarbons) and other environmentally harmful fractions such as heavy metals. The release of CFCs to the atmosphere is considered hazardous since CFCs cause ozone depletion, which increases the risk of skin cancer.	Households and enterprises
End-of-life vehicles	No	80 % recycling of waste amounts Environmentally safe management of harmful fractions Only specific fractions of discarded vehicles are hazardous. Especially fractions containing heavy metals or acids. Different waste fractions are generated both before and after shredding (scrapping) of vehicles.	End-of-life vehicles contain many environmentally harmful substances. These are especially heavy metals that today end at waste incineration plants or landfills	Households and enterprises End-of-life vehicles contain waste such as iron and metal parts, tyres, plastic, glass, oil, and other liquids.
Shredder waste	Partly	75 % recycling and better resource utilisation of shredder waste Reduced amounts of shredder waste for landfilling	Shredder waste can have a high content of environmental contaminants (heavy metals, PCB). The possibility of developing new treatment techniques is being investigated.	Shredder plants Shredder waste is generated at enterprises crushing various metal-containing products, such as vehicles and hard white goods (kitchen hardware).

Waste Category	Defined as hazardous waste	National objectives in 2004	Environmental problem / Health aspects	Source
Foundry waste	Partly (Yes)	80 % of recycling of foundry waste 10 % waste reduction	Foundry waste contains chemicals and this is a barrier to recycling. Today, foundry waste accounts for a large part of landfilled industrial waste. Environmental problems primarily derive from discarded foundry sand, slag and filter dust. Filter dust are classified as hazardous waste. Technically, the majority of waste generated at foundries can be recycled. Foundries in Denmark are encouraged to make efforts to recycle waste in co-operation with DEPA.	Foundries Foundry sand amounts to 80,000 tonnes per year Around 5,000 tonnes of slag and 400 tonnes of furnace filter dust are generated each year.
Packaging waste	No	Quantitative objectives are set up for 2001. Contrarily to many other countries, Denmark has chosen to focus on the best way to utilise various recyclable materials in waste including packaging waste, instead of establishing a separate system for packagings.	Packaging waste contains large quantities of reusable packages and recyclable materials.	Households and enterprises

Fractions have been selected because of their potential health effects. Not all waste fractions for which specific requirements exist have been described in the table above.

Legislative documents and provisions for specific waste functions

Waste Category	**Legislative Documents**	**Legislative Provisions** **For each of the mentioned waste fractions, Danish municipalities set up provisions in individual by-laws (regulations).**
Health-Care risk waste	Statutory Order on Waste, no. 619, 27 June 2000. Detailed guidelines on health-care risk waste is based on Guideline no. 4, 1998.	Provisions as for other categories of hazardous waste: Municipality shall initiate collection from source. Enterprises shall report all hazardous waste to the municipality. Healthcare risk waste is defined in the guideline.
PCB and PCT	Directive (96/59/EC) on PCBs and PCTs Statutory Order on PCB, BCT and substances, no. 925 of 13 December 1998	Regulates the decontamination or disposal of equipment containing PCBs and/or the disposal of used PCBs in order to eliminate them completely. Decontamination and/or disposal of large PCB volumes (> 5 dm^3) must take place at the latest by the end of 2010. Equipment containing < 5 dm^3 of PCB must be disposed of at the end of the product's useful life. These measures aim to reduce and prevent the dispersal of PCBs in the environment, which are highly toxic and bioaccumulate in fat issues. Importing and marketing PCB and equipment containing PCB has been banned in Denmark since 1986, and the use of condensers and equipment containing PCB above a total weight of 1 kg (or an effect of ≥ 2 kVAr) has been banned since 1995. This means that large condensers and transformers (> 5 dm^3 PCB) do not exist in Denmark, and equipment with a PCB content of >0.05 % by weight must be decontaminated as soon as possible.
Waste oil	The Directive on the disposal of waste oils (75/439/EEC, and amendments) Statutory Order on Waste.	Prohibits any discharge or treatment of waste oils causing a risk of pollution. Where discharges are unavoidable, measures must be taken to ensure the safe collection and disposal of waste oils. Waste oil in Denmark is collected to be recycled at district heating plants and/or incinerated. A subsidy scheme also exists for waste oil that encourages incineration at district heating plants.

Waste Category	Legislative Documents	Legislative Provisions **For each of the mentioned waste fractions, Danish municipalities set up provisions in individual by-laws (regulations).**
PVC	Statutory Order on Waste	Municipalities shall collect PVC waste from households, and shall assign PVC from enterprises. Recyclable PVC shall be recycled, non recyclable shall be deposited at sanitary landfills.
Impregnated wood	Statutory Order on Waste	Municipalities shall collect impregnated wood from households, and shall assign impregnated wood from enterprises to depositing at sanitary landfills. Only for creosote impregnated wood, incineration is permitted.
Batteries and accumulators	Batteries are regulated both via legislation and via agreements and economic instruments. Directive on batteries and accumulators (91/157/EEC). Statutory Order on Waste Statutory Order on certain batteries and accumulators that contain hazardous substances, no. 1044 of 16 December 1999. Statutory Order on collection of Lead Accumulators and Subsidy to Collection and Disposal for Recycling, no. 91 of 22 February 1996. Statutory Order on Fees on Lead Accumulators, no. 92 of 22 February 1996. Statutory Order on Collection of Hermetically Sealed Nickel-Cadmium Accumulators and Remuneration for Collection and Disposal for Recycling, no. 93 of 22 February 1996.	Requires the establishment of collection schemes and separate treatment and disposal of spent batteries and accumulators containing mercury, cadmium or lead. The Statutory Order ban import and sale of batteries with a heavy metal content above specific weight limits Lead Accumulators and Ni-Ca Batteries shall be collected for recycling. Remuneration is paid to public and private enterprises collecting the batteries.

Waste Category	Legislative Documents	Legislative Provisions **For each of the mentioned waste fractions, Danish municipalities set up provisions in individual by-laws (regulations).**
Waste electrical and electronic equipment	Statutory Order on management of waste from electrical and electronic products, no. 1067 of 22 December 1999. The European Commission has adopted a proposal for a Directive (COM(2000) 347)8.	The Statutory Order is expected to increase the recycling of heavy metals contained in waste from electrical and electronic products: around 25,000 tonnes of WEEE per year, corresponding to 40 % of copper landfilled today, is expected to be recycled. Separate treatment of WEEE is also expected to improve the possibility of recycling slag from incineration plants. The proposed Directive aims to increase the recycling of WEEE. Consumers will be able to return their equipment free of charge to producers, who will be responsible for taking back and recycling WEEE. This will provide producers with an incentive to design electrical and electronic equipment in an environmentally more efficient way. In order to prevent the generation of hazardous waste, the use of certain hazardous substances will be restricted and the substitution of various heavy metals and brominated flame retardants in new electrical and electronic equipment from 1 January 2008 onwards will be required.
Refrigeration equipment	Circular on municipal by-laws on disposal of CFC-containing refrigeration equipment, no. 132 of June 13, 1996.	Since 1997, Danish municipalities have been obliged to ensure that at least 95 % of CFC12 is collected for recycling or disposal, and 80 % of the CFC 11 and mercury contacts and condensators are collected for special treatment and disposal.
End-of-life vehicles	(Statutory Order no. 860 of November 29, 1999). Statutory Order no. 141 of February 25, 2000). 1997 draft Directive on end-of-life vehicles.	Since April 2000, owners of end-of-life cars are obliged to deliver them to specific garages and car dealers. Other motorised vehicles must be delivered to enterprises that are certified by the municipality. When delivering an old car, the owner is paid 1,500 DKK. Draft directive aims to prevent waste from end-of-life vehicles and promote the collection, re-use and recycling of vehicle components. The draft Directive provides for the introduction of a system for collecting such vehicles at the manufacturer's expense, in accordance with the polluter pays principle.

Waste Category	Legislative Documents	Legislative Provisions
		For each of the mentioned waste fractions, Danish municipalities set up provisions in individual by-laws (regulations).
Shredder waste	Statutory Order on Waste	Management of shredder waste has so far been regulated by general rules in the Statutory Order on Waste and via the environmental approvals or permits for enterprises dealing with shredder waste, such as iron and metal recycling enterprises, which are considered heavily polluting enterprises (see section below). When treatment methods have been developed, rules will be issued on the management of shredder waste.
Foundry waste	Statutory Order on Waste	Management of foundry waste is regulated by general rules in the Statutory Order on waste and via the environmental approvals or permits for foundries that are considered heavily polluting enterprises.
Packaging waste	Directive on packaging and packaging waste (94/62/EC) Statutory Order on Waste Statutory Order on certain requirements for packaging no. 298 of 30 April 1997.	The Directive includes provisions on prevention and it sets up a number of quantitative objectives for the recycling of packaging waste. Requirements for design of packaging described in the Directive are directed at manufacturers (or importers) of packaging. The purpose of these requirements is to reduce amounts and environmental impact of packaging and packaging waste. The Directive specifies concentration levels of heavy metals in packaging and essential requirements on the composition and nature of packaging. Rules on management and recovery of packaging waste in Denmark are included in the Statutory Order on waste and requirements for manufacture and composition of packaging are laid down in the Statutory Order on packaging.