WATER SERVICES IN FINLAND

Domestic water supply and sewerage

FINNISH ENVIRONMENT INSTITUTE

FINNISH WATER AND WASTE WATER WORKS ASSOCIATION

CONTENTS

More to read on Finnish Water Services:
Katko, T. 1997, Water; Evolution of Water Supply and Sanitation in Finland from the mid - 1800s to 2000.
Finnish Water and Waste Water Works Association, 1997.

Fresh water is now and will be one of the scarcest and most important natural resources in the future. Global water resources are distributed very unevenly on the earth. Africa and the Middle East in particular suffer from shortage of fresh water. In Europe also there are countries facing water scarcity problems, but it is in developing countries that the consequences of water shortage are most devastating. Most diseases causing death are related in one way or another to the lack of safe drinking water, sewerage systems, proper latrines and hygiene.

Despite water scarcity, safe drinking water as well as adequate hygiene and sanitation must be offered to everyone on earth. Reaching this goal is a great challenge. Finnish experts in the field of water services will also participate in this work. This brochure aims to give the reader an idea and some data of the work that has been done in Finland to be able to provide water services in a country with a sparsely settled population and cold climate, but, luckily, with abundant water resources. In addition, some ideas for the future are presented.

Finland is rich in forests and lakes. Lake Pielinen.

FINLAND - THE LAND OF FORESTS AND LAKES

Finland is situated in Northern Europe, by the Baltic Sea. Finland's neighbouring countries are Sweden to the west, Norway to the North, Russia to the East and Estonia to the South, across the Gulf of Finland. A quarter of its total area lies North of the Arctic Circle.

Due to the influence of the Baltic Sea and westerly winds from the Atlantic warmed by the Gulf Stream, the climate is milder than that of most other areas of the same latitudes. The mean annual temperature is about 5.5°C in Southwestern Finland, decreasing

Typical view of a Finnish groundwater area.

towards the Northeast. In Northern Finland the mean annual temperature is below 0°C. Temperature differences between regions are greatest in January, about 12°C between Southern and Northern Finland. The lowest temperatures in winter are from -45°C to -50°C in Northern Finland. The lakes freeze over in late November and early December. The ice on the lakes is thickest in early April, about 50 to 65 cm.

The total area of the country is 338 000 square kilometres (131 000 square miles) and the population is approximately 5.3 million. Population density is a modest 16 persons per square kilometre (40 per sq. mile) but it differs considerably from region to region. The population density in the southern part of the country is over 100 persons per sq. km (260 per sq. mile), while in the most northerly part of the country, Finnish Lapland, the population density is only 2 persons per sq. km (5 per sq. mile). Most Finns, more than 80 % of the total population, live in towns and villages.

Finland is known as a land of forests and lakes. Forests cover roughly three quarters of the country's surface area and waters cover 10% of surface area. There are thousands of lakes in Finland, most of which are small and shallow. The total number of lakes with an area larger than 1.0 ha (2,47 acre) is 56 000. and 2 600 have an area greater than 1.0 square km (0.386 sq. mile). Much of the country is a gently undulating plateau of worn bedrock and boreal forests, presenting a striking mixture of wooded hills and waters. High rounded fells form the landscape in Lapland.

WATER RESOURCES AND THEIR PROTECTION

In Finland the rainfall is distributed fairly evenly round the year. The average annual rainfall is 660 mm (26 in), resulting in a runoff of 340 mm per year. Thus, the renewable water resources are about 108 000 million cubic metres per year (58 000 litres per capita per day). Only 2% (900 litres per capita per day) of renewable water resources are used by industry (excluding hydropower generation and cooling), agriculture and urban and rural water supply.

More than 10% of the precipitation is infiltrated and forms groundwater. The most important groundwater resources are found within the gravels and sands of glacial sediments located mainly in eskers and ice marginals throughout Finland. The groundwater table is fairly near the ground surface. Usually groundwater is of high quality and it meets the requirements set for household water. However, high amounts of iron and manganese in groundwater often cause aesthetic problems for water supply. These problems arise from the clays covering the eskers. In Finland groundwaters are very soft compared to, for instance, Central Europe where the content of limestone in bedrock is high. Therefore, some pH adjustment is usually needed for corrosion control before pumping to the distribution system.

There are thousands of aquifers in Finland but their yields are relatively low and most of them have an area of just a few square kilometres. All in all 7 100 groundwater areas are classified into three groups: areas important for water supply (class I), areas suitable for water supply (class II) and other groundwater areas (class III). The total water yield of all the classified groundwater areas is approxi-mately 5.8 million cubic metres per day (more than 1 100 litres per capita per day). About half that amount is the yield of areas classified as important for water supply. In 1996, waterworks used 0,65 million cubic metres of groundwater per day corresponding to 23% of the total water yield of these important groundwater areas.

Over the years, many establishments, and activities such as manufacturing, storage and treatment of noxius substances, agriculture, forestry, roads, waste management and soil extraction harmful to the groundwater have grown up in Finnish groundwater areas. The mapping and classification of groundwater areas provides the information required for improving water supply plans. The aim of these plans is to safequard the water supply, even in a crisis situation. The classification of groundwater areas is very important to the authorities responsible for the supervision of water resources. It will help them to direct their limited resources to the most important targets. Groundwater areas have also been taken into consideration in spatial planning by regulating different forms of land-use and activities and by issuing orders affecting land-use.

Despite the large number of lakes in Finland the water volume they can hold is considerably low due to the shallowness of the lakes. The average depth of lakes is about 7 m (23 ft) and the total volume is 230 km^3. Surface waters in Finland are mostly clear, with a low nutrient content, or slightly brown, with a high humus content. Particularly in the western part of the country surface waters are rich in humus. This is a problem, if surface water is used for water supply.

Finnish lakes are (due to their natural quality characteristics, low volumes and a long-lasting ice cover which diminishes the oxygen exchange from the air) sensitive to pollution and eutrophication. However, by international comparison, the quality of Finnish surface waters is rather good and there are no problems with pesticides for example, that are typical in countries with very intensive agriculture.

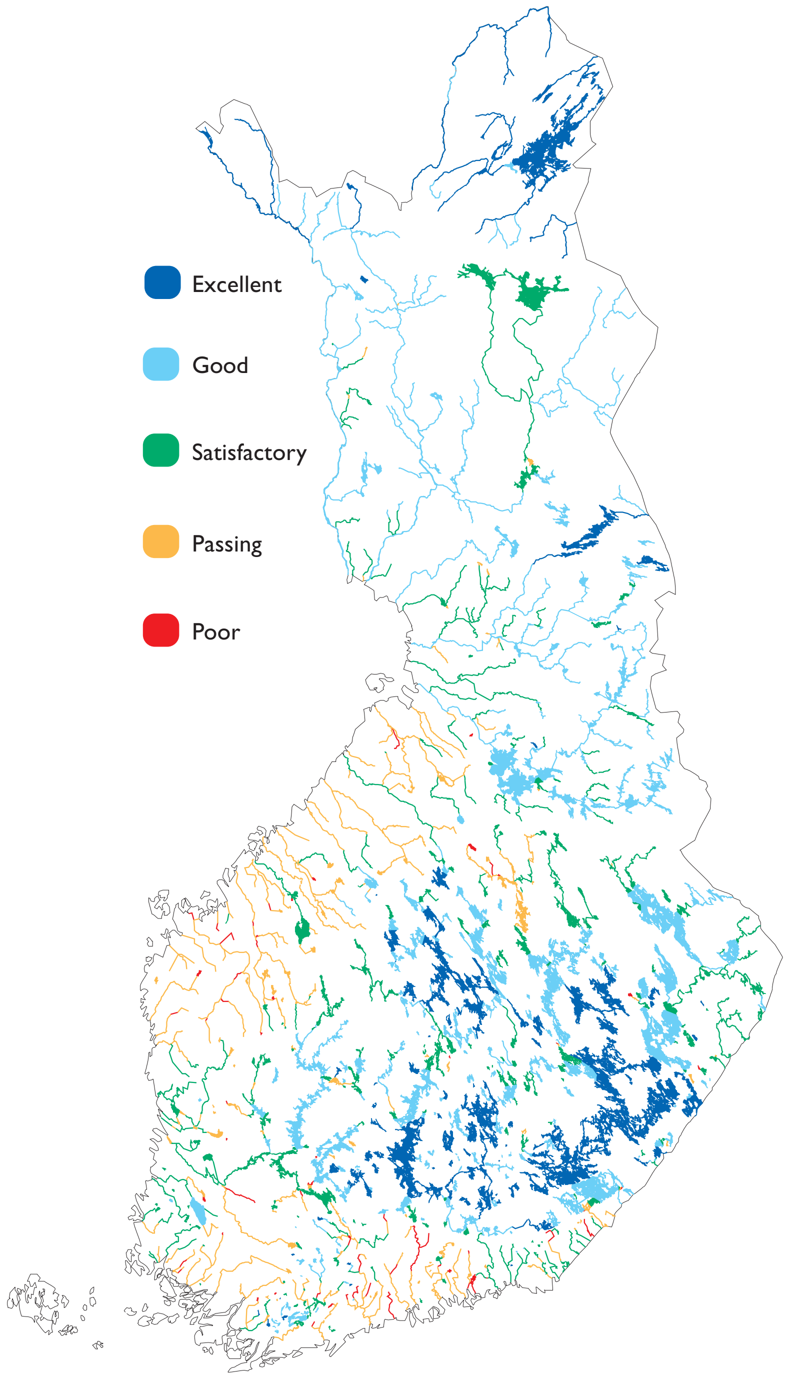
The general water quality classification made on the basis of data from 1990-1993 showed that eutrophication had increased in the waters under the influence of non-point loading (agriculture and sparsely populated areas without public sewerage services etc.) but had decreased in the waters influenced by point-loading (industries and population centres) as compared with the situation prevailing five years before. On the whole, the quality of Finnish surface waters has improved considerably since the 1970s. In the early 1990s, some 38% of the surface area of Finnish lakes were classified as excellent, 43% as good, 16% as satisfactory and only 0.3% as poor. The rivers were typically of lower quality than lakes.

The water quality classification of Finland waters is made on the basis of oxygen content, colour, turbidity, nutrients, hygienic indicator bacteria, chlorophyl ***a***, algal blooms and toxic compounds. Data for the classification is obtained from altogether 3 800 observation sites covering the whole country. It provides an overall picture of water quality and describes the suitability of waters for water supply, fishing and recreational activities.

LEGISLATION

Since 1961 the use of waters and their protection have been regulated by the Water Act. It contains rules on water management, public use and all kinds of water-related construction, like hydropower, regulation, flood control and water supply, as well as water pollution control. The use of surface water is governed by public use rights and stipulations based on this law. The Water Act involves a permit system for water abstraction and wastewater discharge. Groundwater is not owned by anyone, but the landowner has right of priority to use it as water supply.

The three special Water Courts, created in 1962, are important for the application of water legislation



Water quality in lakes and rivers.

because they act both as administrative permit authorities and as special civil and criminal courts. The Water Court consists of lawyers, engineers and biologists. The Courts are independent of the national environmental administration. The appellate courts for the permit procedures are the Superior Water Court and ultimately the Supreme Administrative Court.

The Act on Public Water and Sewage Works defines the local authorities' obligation to take care of water services. Specifically, this legislation states that the municipality is obliged to organize water services if required for reasons of health or the need of a larger group. The law requires each local authority to define the area of operations of water services within its municipal boundaries.

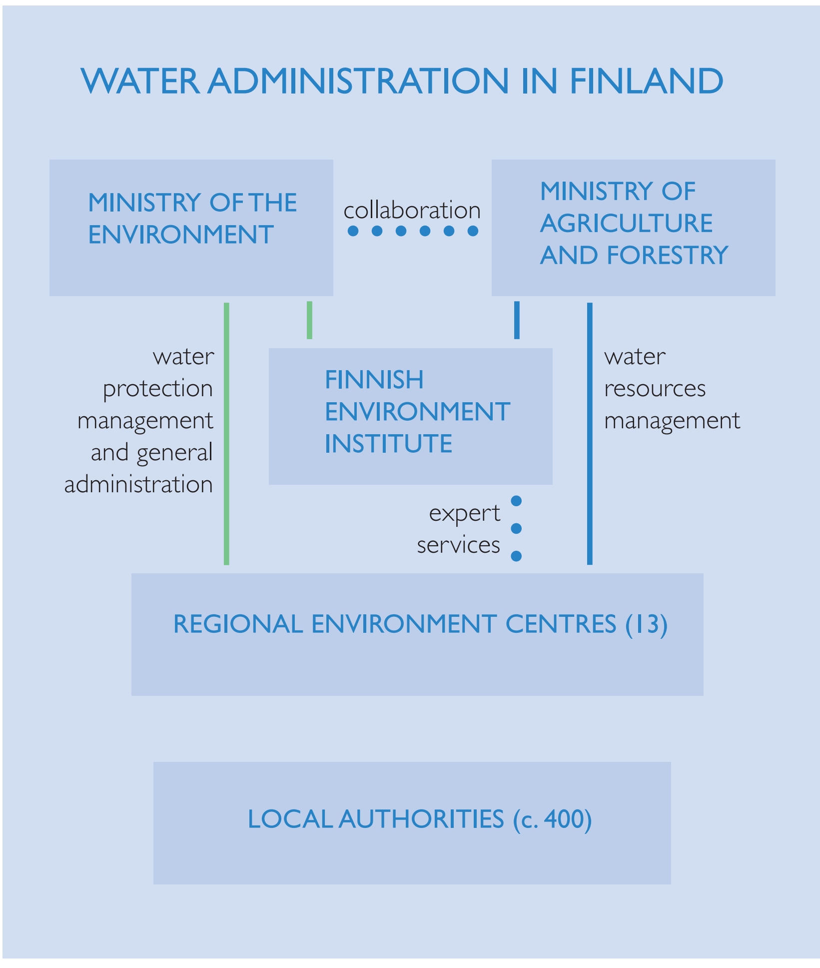
Drinking water quality is regulated by the Public Health Act and Decree. The Act stipulates that the state authorities will lay down quality requirements for domestic water to be observed by the water works.

In 1995, after Finland joined the European Union, and even before, water sector legislation was modified to comply with Council Directives. For instance, Finland has chosen to adopt some stricter requirements than those set out in the directives concerning urban waste water treatment and drinking water.

ADMINISTRATION IN WATER AND ENVIRONMENT ISSUES

In 1995 Finland's Environmental Administration was reorganized. The Finnish Environment Institute (FEI) was founded on the basis of the former organization of the National Board of Waters and the Environment. In conjuction with the founding of the FEI, the Water and Environment Districts subordinate to the National Board of Waters and the Environment and the Environmental Offices of Provincial Governments were regrouped into 13 Regional Environment Centres. The Regional Environment Centres are the licensing and supervisory authorities regarding environmental matters and they are also in charge of duties related to nature protection and water resources management in their region. The FEI and the regional environment centres are under the general administration of the Ministry of the Environment. One of the duties of the ministry is to develop and enhance water protection planning and pollution control measures, including wastewater treatment. The Ministry of Agriculture and Forestry is in charge of duties related to the use and management of water resources, including water supply and sewerage. On these issues, the Ministry of Agriculture and Forestry sets targets to the FEI and the regional environment centres and collaborates with the Ministry of the Environment.

The Ministry of Social Affairs and Health is responsible for setting national quality requirements for drinking water and monitoring obligations, according to which quality surveillance is carried out by the municipal health authorities.



THE FINNISH ENVIRONMENT INSTITUTE (FEI)

The Finnish Environment Institute is currently Finland's leading institute of environmental research and development. In addition, the FEI's main duties consist of monitoring the state of the environment, including surface waters, groundwaters and pollution loading, as well as of various expert services, environmental education, the upkeep of data registers and international cooperation.

The FEI cooperates with research institutions, universities, authorities and organizations both in Finland and abroad. The FEI is, for example, the national focal point for the European Environment Agency. There is also active cooperation with neighbouring countries, Nordic and Arctic cooperation as well as cooperation under the agreements for the protection of marine areas, like the HELCOM convention. The FEI also offers international consulting services for Finnish development cooperation projects, for example, and in neighbouring regions and countries including several EU-programmes.

The FEI comprises twelve divisions. Tasks relating to water supply and sanitation are handled in the Pollution Prevention Division that is subdivided into seven units. These are water services unit, groundwater unit, waste unit, environmental management unit, soil unit, industrial unit and environmental geotechnics unit. The main duties of the water services unit are research and development of water and wastewater treatment methods, water distribution and sewerage networks as well as water services and environmental protection in rural areas. The ground water unit carries out research and development work associated with groundwater and artificial groundwater. Its aim is to promote the use of groundwater in water supply and to take care of groundwater protection. Both units also provide expert services and training for the use of both the public and private sector. The units also participate in domestic and international projects.

FINNISH WATER AND WASTE WATER WORKS ASSOCIATION (FIWA)

The FIWA is a nationwide joint organization of water and wastewater works. The members of FIWA cover about 80 % of the volume of the Finnish water services. The main duties of FIWA are:

- *to promote the common interests of its members,*
- *to prepare technical and administrative guidelines for its members use,*
- *to promote research activities,*
- *to provide information,*
- *to advise and to help its members in technical, administrative and juridical matters,*
- *to provide supplementary education and training courses for water services personnel and management of international affairs.*

The representatives of the member utilities participate in the activities of the FIWA in several Working Groups. The FIWA cooperates intensively with national and local authorities and research institutes.

The FIWA is the representative of Finland in the IWSA (International Water Services Association) and in the EUREAU (European Union of National Associations of Water Suppliers and Waste Water Services).

ADMINISTRATION AND FINANCING OF WATER SERVICES

ADMINISTRATION AND MANAGEMENT OF THE WATER SERVICES

According to the Act on Public Water and Sewage Works local authorities are responsible for providing water services. The Municipal Council determines the operating area of public waterworks and sewage works and they then take care of water services in that area. All municipal water and sewage works are public but also private water or sewage works can be accepted as public works. Usually the water services are included in the municipalities technical organization.

There are more than 700 waterworks and 500 sewerage works each serving more than 200 people in Finland. Over 90% of the total amount of water is supplied by municipal waterworks. There are a few limited liability water companies owned by the municipalities. They have their own organization separate from the municipal one. In rural areas there are more than 400 small waterworks, cooperatives and limited liability water companies owned by the users. Wastewater services are mainly publicly owned. In rural areas there are a few cooperatives. Industry and other water users, such as hospitals and army bases, also own and manage a few water and sewage works.

There are also several forms of inter-municipal cooperation in water services. For instance, some wholesale companies owned by neighbouring communes abstract and treat water and sell it to the local public waterworks. They do not sell water directly to the consumers. There are also bilateral agreements on the buying and selling of water and discharging or receiving wastewater in case of centralized treatment.

The arctic environment in Northern Finland sets special requirements for construction of water supply and sewerage in tourist centres.

Costs and Financing

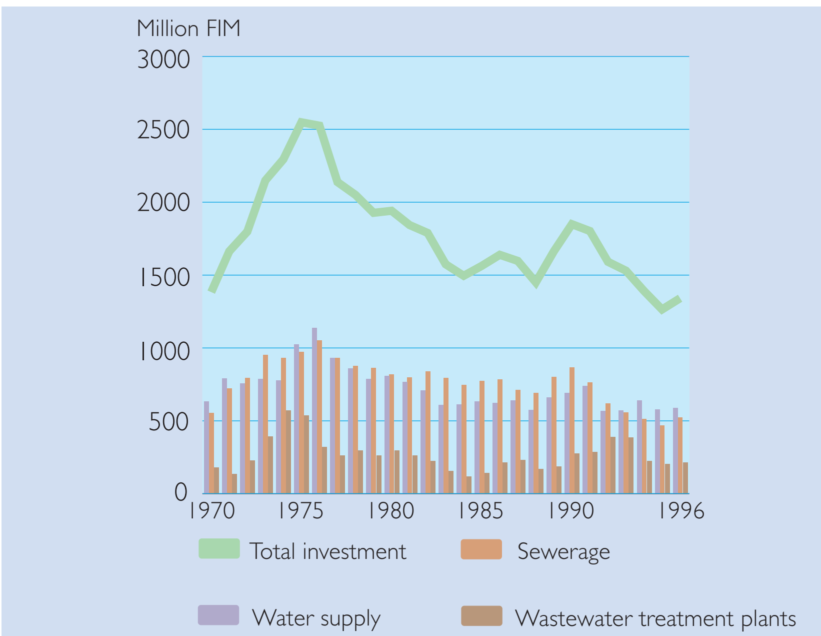
Water services are highly capital-intensive: some 80-90 % of the total expenses are fixed, i.e. independent of water consumption. Extension and improvement of water services have necessitated considerable investment over the years. The peak of investment was reached in 1975, when a record number of wastewater treatment plants were constructed. In 1996, the total investment in water services was 1325 million FIM (equivalent to about 260 million U.S. dollars or 220 million ECU) corresponding to some 250 FIM (48 $, 42 ECU) per capita. Of the total, 44% was invested in the water supply, 40% in sewerage systems and 16% was invested in wastewater treatment plants.

Most public waterworks are operated on a commercial, though non-profit-making, basis. The cost of services, both investments and operation costs, is presently covered by direct customer fees. Earlier local taxes were also used for financing the construction of water and sewage works.

Even though waterworks seldom have problems with the availability of water, all the water sold is metered when entering the customers building. Usually the apartment houses have only one meter, but in some cases every household has its own meter. Both water and wastewater charges are based on water consumption. Most water and sewage works, except some large and middle-sized towns, also levy connection charges. The same is true for cooperatives and other associations. The most recent trend is that the waterworks are introducing also a fixed fee which is independent of consumption.

At the beginning of 1997, the average price of water was about 6 FIM/m^3 (equal to 1 ECU or 1.20 USD), when increments caused by metering, fixed fees etc. are included. The average wastewater charge at that time was about 7 FIM/m^3 (equal to 1.15 ECU or 1.40 USD). Both charges presently include 22% value-added tax.

In Finland the state gives some subsidies to the water services investments. This government support has now been directed mostly to investments in smaller municipalities, with higher subsidy percentages in the northern and eastern parts of the country, and to important inter-municipal systems. The present total share of all forms of government support to the water services is well under 10 % of the total yearly investments. No governmental subsidies are available for operation and maintenance.



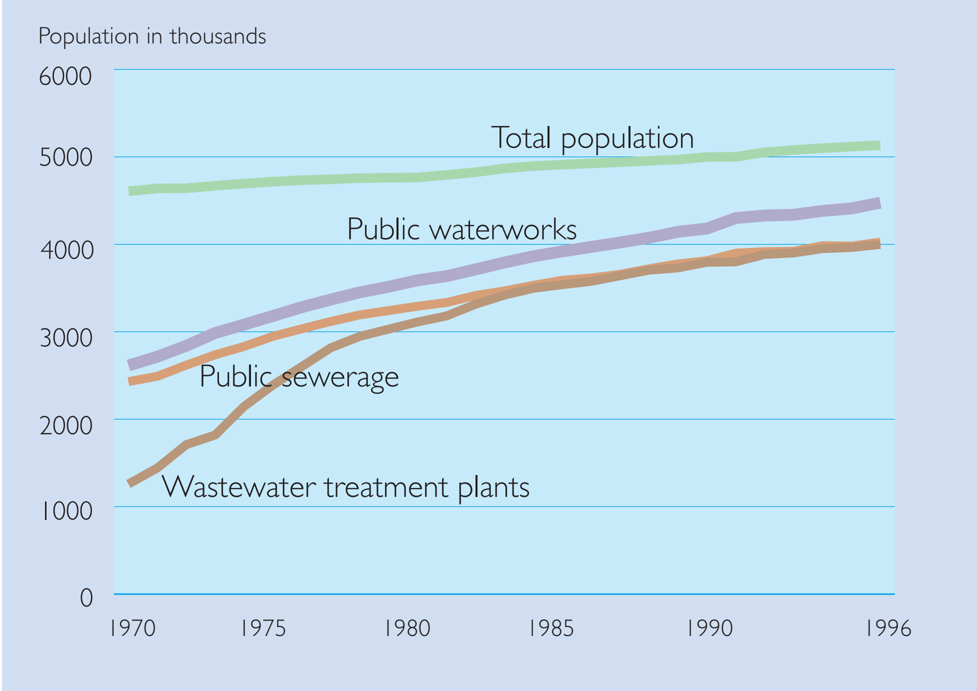
Total investments in the public water services, 1970 –1996.

DATA COLLECTION AND REGISTERS

Countrywide data on water and sewerage works serving at least 200 persons have been collected since the end of the 1960's by the Finnish Environment Institute and its predecessors. Since 1994, data collection has also involved smaller water and sewerage works, serving 50 to 200 persons. The Regional Environment Centres send questionnaires every year to the water and sewerage works in their region. The compilation and national overviews are made by the FEI.

The Water and Sewerage Works Register contains general information on the water and sewerage works, their investments, fees, networks, water intakes, water and wastewater treatment. The information on the development of Finnish water services (1970-1996) in this brochure is based for the most part on this register. There are also other registers which contain information on the performance of sewer networks and pollution data on treatment plants as well as information on water intakes, and quality of the drinking water.

One register has been modernized recently and the others are under the process of modernization. Throughout the modernization, the statistical information on the registers will be combined with supervision and monitoring. Water services and water pollution control registers will be developed from the present statistical-supervision tool towards multi-purpose vision-creating registers of the future.



Population served by public waterworks, sewerage systems and wastewater treatment plants, 1970 – 1996.

COVERAGE OF WATER AND SEWERAGE SERVICES

Sanitary standards in homes in Finland are fairly high. Piped water is available in 97%, and sewer system in 98%, of Finnish households.

In 1996, about 87% (4.5 million people) of the population of Finland were connected to the public water distribution network. The others take drinking water mainly from private wells. Public sewerage systems served about 4.0 million people, which accounted for 78% of the total population.

Due to long distances in sparsely populated areas and the abundance of water, the percentage figures of public water service's coverage are rather low compared to many other European countries. However, the amount of inhabitants served by public water services has continuously increased in Finland. The coverage of public water services in densely populated areas is almost 100%.

WATER ABSTRACTION AND DRINKING WATER TREATMENT FOR PUBLIC WATER SUPPLY

GROUNDWATER

The use of groundwater and artificial groundwater for the public water supply has continuously increased over the period for which comprehensive statistics are available (1970-1996). At the beginning of 1970s the share of groundwater was only 30% but in 1996, slightly more than 56% of total water abstraction by public water works was groundwater or artificial groundwater. Of the 1 560 separate water sources in the country nearly 1 500 are groundwaters sources. The percentage of groundwater or artificial groundwater as raw water in public water utilities is foreseen to rise to about 70% by the year 2010.

In the coastal areas the amount of available good-quality groundwater is often limited. To serve these areas, several water supply systems using artificial groundwater have been constructed. They account presently for about 8% of the total water abstraction by public water utilities.

Groundwater has typically a low alkalinity, the average pH being 6.5, but lower concentration of humic substances than surface water. Most waterworks, especially the small ones representing 35% of the abstracted groundwater, deliver it untreated. If groundwater is treated, typical processes consist of pH-adjustment with lime or sodium hydroxide addition or with limestone filtration. Regionally, many water utilities have to remove iron and manganese. Pesticides and nitrates do not yet present a problem for the public water supply in Finland. The removal of iron and manganese usually includes aeration and sand filtration or slow sand filtration alone.

A natural spring.

Groundwater is rarely disinfected. An increasing number of water utilities are introducing UV-disinfection in the plants where seasonal variation of water quality occurs. However, there are only a few waterworks using groundwater or artificial groundwater that practice secondary disinfection with sodium hypochlorite.

Surface Water

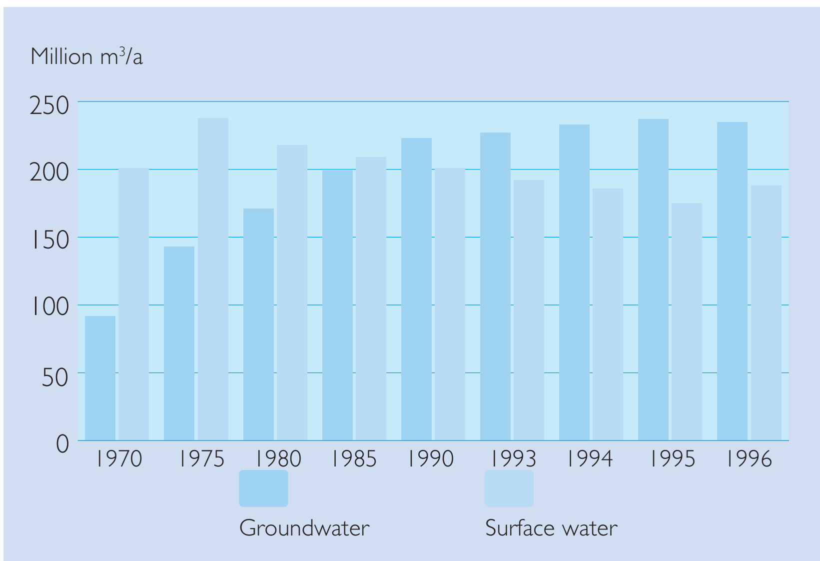
Surface water is used mainly in some larger cities. The number of surface water sources is only about 70, but they represent more than 43% of the distributed water. For instance, about one million people in the Helsinki metropolitan area use water from Lake Päijänne. The rock tunnel of 120 km in length brings the raw water to Helsinki water treatment plants.

The surface water is soft with low alkalinity. This raises the need for carbonation and hardness addition in some cases for pH and corrosion control. Low water temperature necessitates optimal design and operation of water treatment processes.

The major challenge of treatment plants utilizing surface water is the removal of humic substances. The average concentration of total organic carbon in Finnish lakes is 15 mg/l. Most plants remove humic substances by conventional chemical treatment, which means that the treatment train consists of coagulation, sedimentation/flotation and sand filtration. Flotation is often performed instead of sedimentation, which is partly due to the long history of developing Finnish flotation technology. As a consequence, Finland is one of the leading experts in dissolved-air flotation. Coagulation is traditionally performed with aluminium sulphate, but an increasing number of plants are shifting towards the use of ferric salts. Practical experience at many waterworks has shown that higher removal of humic substances can be achieved with ferric coagulants.

In the coastal areas surface water is taken mainly from rivers and small lakes and is thus subjected to high seasonal variation. In such cases the treatment process is often upgraded with some kind of combination of ozonation, activated carbon and slow sand filtration. Ozone is applied either as a pretreatment for algae control or as intermediate or post-ozonation for primary disinfection and taste and odour control. The importance of the efficient control of bluegreen algae blooms has increased during the past few years.

Primary disinfection is mainly carried out at the final stage with chlorine or at the intermediate stage with ozone. Exceptionally, Helsinki Water has the largest UV-disinfection application in the world as an additional disinfection barrier between activated carbon filtration and chloramination. Prechlorination is no longer practiced in any of the drinking water treatment plants. Secondary disinfection is normally per-



The use of surface water and groundwater as raw water in the public water supply, 1970 – 1996.

formed either with chloramines or chlorine. Due to higher stability and lower trihalomethane formation in the distribution system chloramine has been an interesting alternative for the protection of microbilogical water quality in the distribution network. However, the doses used for secondary disinfection are quite low (0.3-1.0 mg/l) resulting in low disinfectant residual (0-0.2 mg/l) in the distribution system.

The quality of drinking water

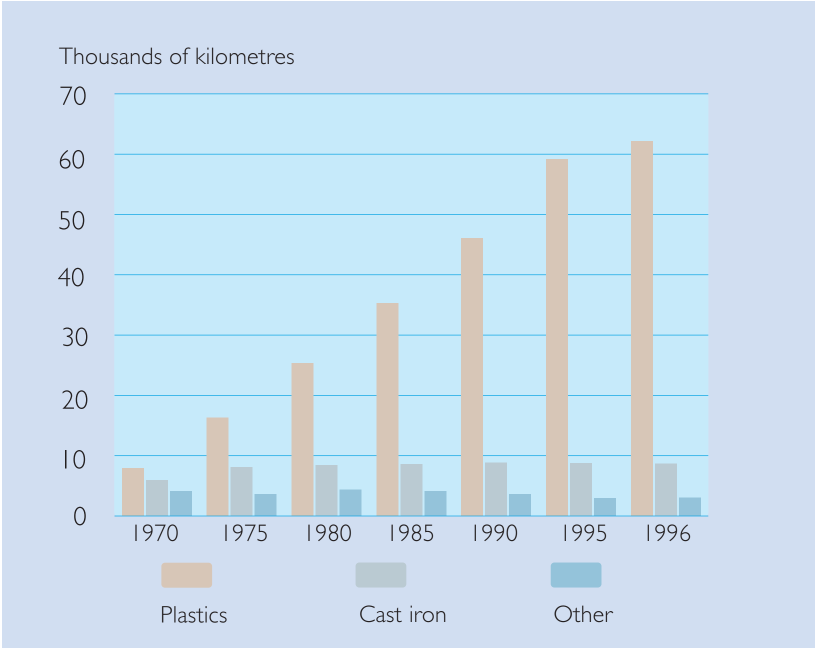
The local authorities monitor regularly the quality of drinking water and report the results to the regional health authorities. In order to improve the reporting required by the Drinking Water Council Directive, the data on water quality of the year 1996 were entered into a national drinking water quality register. The results, published as a report at the beginning of 1998, indicate that both the microbiological and chemical quality of the drinking water is good, on average. Problems that were detected are mostly caused by natural soil conditions, bad condition of the distribution network or pollution of the water source. These problems occur mainly at small treatment plants and they affect only a small fraction of the population connected to public water supply.

WATER DISTRIBUTION AND SEWERAGE NETWORKS

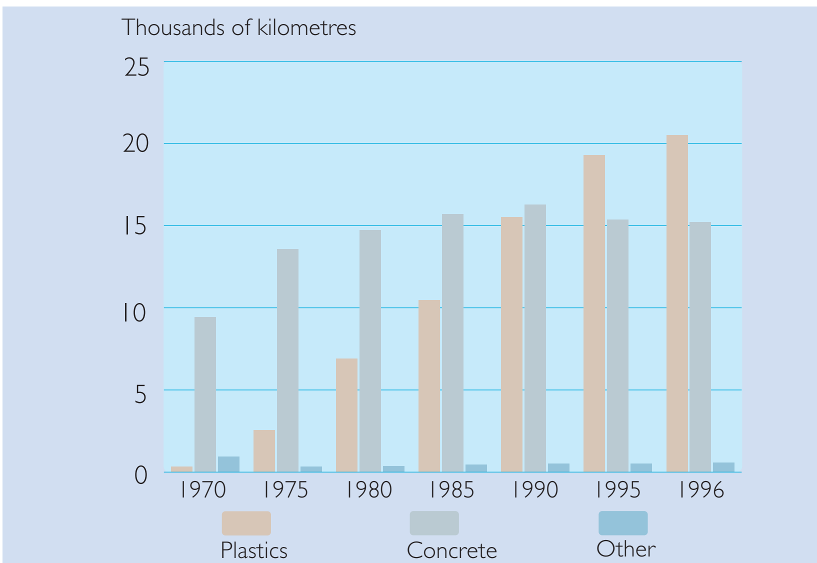
According to the most recent nationwide statistics (1996) the total length of water pipelines was about 74 000 km, excluding house connections. The length of water pipes per inhabitant was 17 metres. Almost 85% of water pipes were made of plastic (PEH and PVC) and approximately 12% of cast iron. Lead pipes have never been used in Finland.

In 1996, the total length of the public sewerage system (including sanitary, storm and combined sewers, excluding house connections) was about 36 000 km of which combined systems accounted for some 8 %. The length per inhabitant was almost 9 metres. Of the total length of public sewers, 57% were made of concrete and 42% of plastic (PVC and PEH).

During the 1990s the annual construction figures of new networks are about 2500 km of water pipes and 700 km of sewers in Finland. Almost all new pipelines are made of plastic pipes. The relative share of plastic pipes in water supply and sanitation in Finland is higher than in any other Western European country. This can be partly explained by the low population density and also the fact that domestic manufacturing and the development of plastic



The length and material of water pipelines, 1970 – 1996.



The length and material of sewers, 1970 – 1996.

pipes has made them very cost-effective.

Although the majority of water pipes and sewers were constructed in the 1960s or later, it is estimated that about 8% of water pipes and some 15% of sewers are in bad condition. Rehabilitation is needed for various reasons.

Even though there are combined sewers for wastewater and storm water only in city centres, storm water and leakages account for nearly 40% (ranging between 25% and 80%) of total sewage flow. Due to the improvements made in leakage control and rehabilitation methods, the total volume of storm water and leakages into the sewers has not substantially increased over the last fifteen years although the length of sewers has increased by almost 70%.

Water towers are prominent parts of the water distribution system in Finnish municipalities. Espoo.

WATER CONSUMPTION

Until the end of the 1980s the total annual water abstraction by public water works was increasing in Finland, when the waterworks had to meet the demand of a growing number of inhabitants covered by the public water services. However, since the beginning of the 1990s, the total water abstraction has been quite constant even though the number of inhabitants served by waterworks has continued to increase.

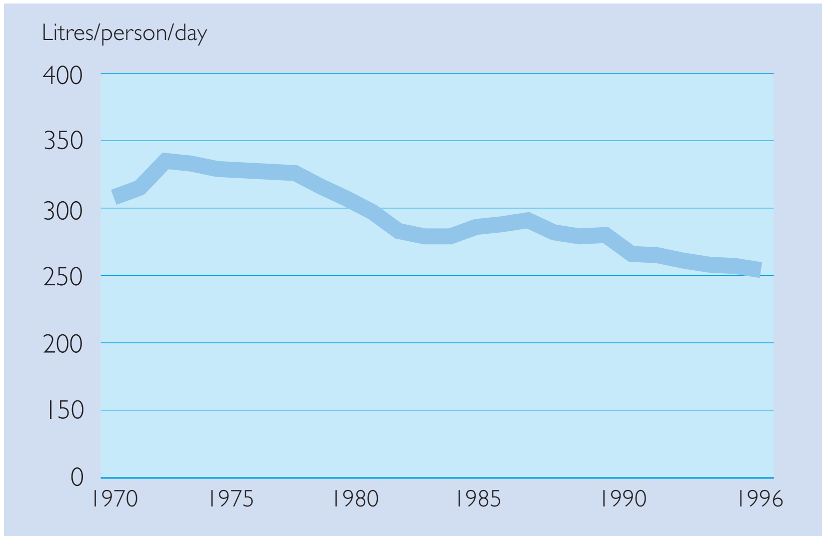
In Finland the specific water consumption has been a key concept in planning future actions such as development of infrastructure, treatment plants or tariff structures. The specific water consumption is the total average daily water distribution divided by the number of persons connected to the distribution network. It includes domestic consumption, industrial consumption, so called general water consumption encompassing unaccounted system losses, leakages, water used for network maintenance as well as water for public services, such as fire fighting and irrigation of public parks. Over the last fifteen years the general water consumption, including leakages, has accounted for 15 to 20% of the total consumption.

In 1996, the specific water consumption was 255 litres/person/day. Throughout the 1990s specific water consumption has decreased by 10%. The peak of specific water consumption (335 l/p/d) was attained as early as 1972.

There are many reasons for the decrease in specific water consumption. In the early 1970s the new wastewater charge almost doubled the price of water. The worldwide energy crisis in the mid-1970s and later ecological thinking have changed consumers habits. In 1994, the imposition of the value-added tax (22%) on water services resulted in an substantial increase in water price.

Domestic water consumption has been reduced by effective house management and technological developments relating to plumbing and fittings, such as low-flow taps, toilets and shower-heads. In the 1980s household water consumption was about 160 l/person/day and in 1996 the corresponding figure was about 145 l/person/day. Household water consumption accounts for almost 60% of the water distributed by public water works. Household water consumption varies according to the type and age of the building, for instance, and the way water consumption is metered and invoiced. In rental flats people generally use more water than people in single-family houses, which have meters and direct invoicing. Water used by commercial, institutional and recreational facilities have accounted for almost 15% of the total amount of water distributed by public waterworks.

All water supplied to the customer must be fit to drink.



Development of the specific water consumption, 1970 – 1996.

The amount of water supplied by public waterworks to industries has decreased considerably. In the early 1970s industrial water consumption was 20 % of the total amount of water supplied by public water works. Since then, industries have implemented new, more efficient water processes and they are using their own water supply. In Finland large water-using industries such as pulp and paper mills have their own supply and they are not dependent on the public water supply but, textile or food and beverage industries, for instance, usually take their water from public networks. In 1996 the industry was responsible for 10% of the total consumption of water distributed by public waterworks.

URBAN WASTEWATER TREATMENT

Short history

Wastewater treatment started in larger towns during the first decades of the 20th century. The first wastewater treatment plants were established in Helsinki in the 1910s. The first activated sludge plant for municipal wastewaters was constructed in the 1930s. Since then the activated sludge process has been developed for Finnish conditions. Removal of nutrients started in Finland in the 1970s. During the peak period of treatment plant construction in the early 1970s, simultaneous precipitation was introduced in activated sludge treatment plants. In the 1980s it became the most widely used process. In addition, several plants using only chemical precipitation were constructed in the 1970s, but all the presently remaining ones will be converted to utilize biological-chemical methods by the year 2005.

In simultaneous precipitation the biological and chemical stages are carried out in the same basin, thus saving construction costs. The dominant chemical is ferrous sulphate. Other methods are preprecipitation and postprecipitation, where phosphorus is precipitated before or after the biological treatment with aluminium or ferrous chemicals.

Load and Performance of Treatment Plants

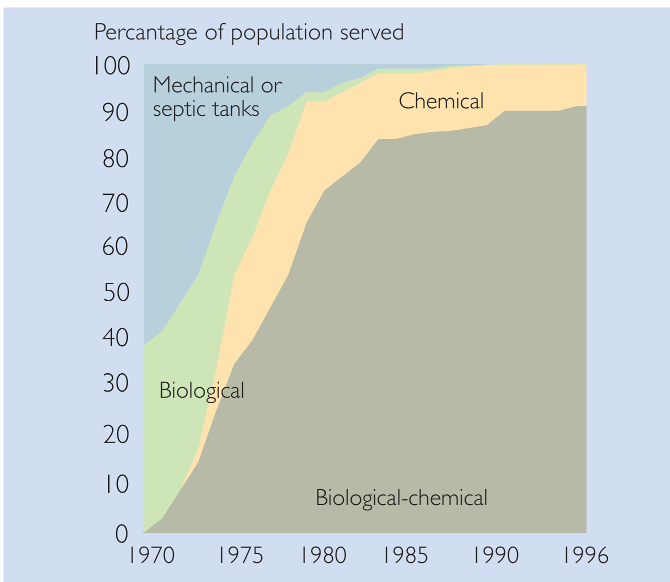
In 1996, wastewater treatment plants treated wastewaters from four million people (78 % of the total population). Wastewaters are

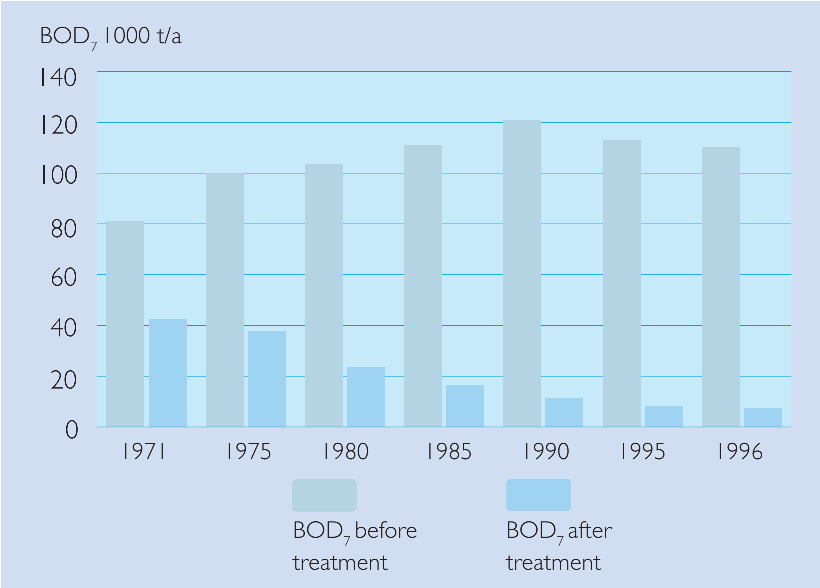
1996	BOD_7			P			N		
	1000 kg/a	kg/pers/a	mg/l	1000 kg/a	kg/pers/a	mg/l	1000 kg/a	kg/pers/a	mg/l
Influent	110,00	28	212	3,700	0,9	7,2	20,900	5,2	57
Effluent	7,500	1,9	15	250	0,06	0,5	14,400	3,6	28
Red.			93%			93 %			31 %

Influent and effluent parameters of municipal wastewater, 1996

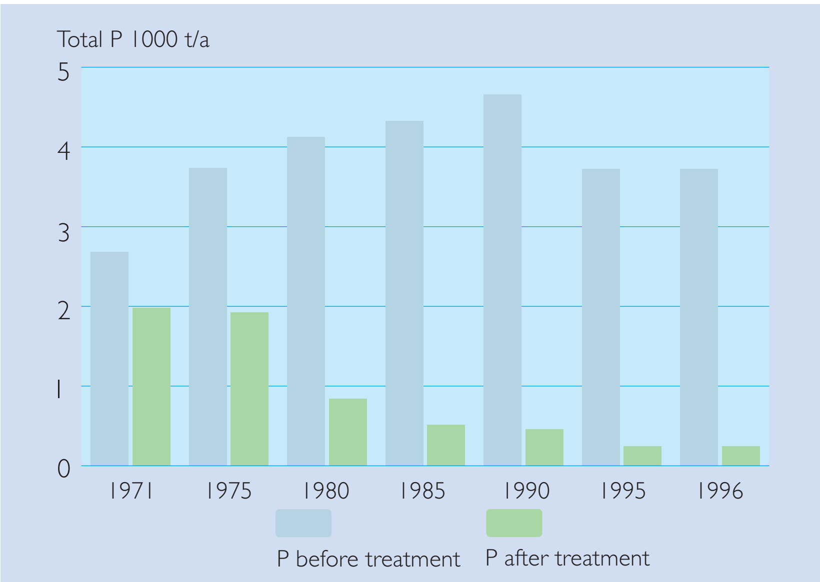
A recently constructed wastewater treatment plant. Kempele.

Development of municipal wastewater treatment, 1970-1996.

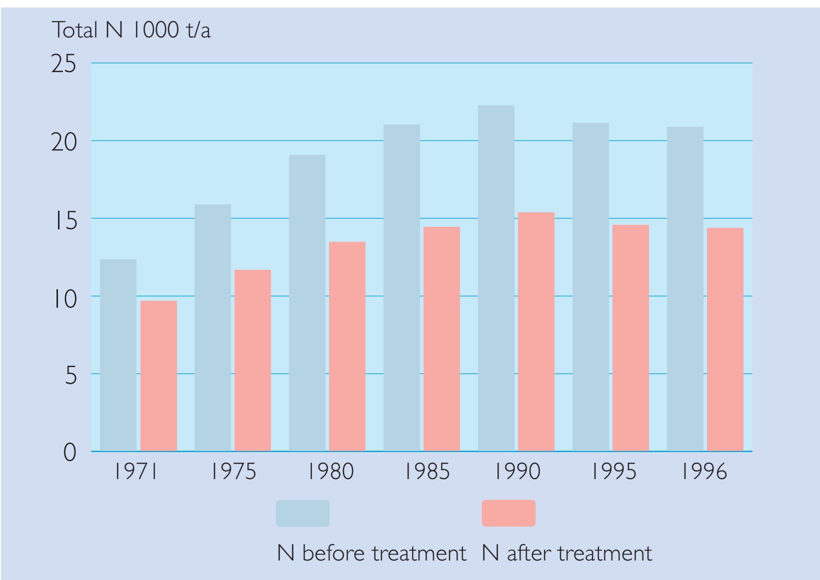




BOD_7 loads before and after treatment in municipal sewage works, 1971 – 1996.



Phosphorus loads before and after treatment in municipal sewage works, 1971 – 1996.



mainly collected by sanitary sewers (separate systems). Very few combined sewers are in use. For storm waters there is no separate treatment. However, during snow melting and rain storms, leakages may affect the operation of treatment plants.

Practically all wastewaters receive effective treatment in Finland. In 1996, almost 90% of the wastewaters received biological-chemical treatment and the rest of wastewaters were treated chemically. Phosphorus removal was carried out on every treatment plant. Transformation of ammonia into nitrate (85-90 % reduction of ammonia nitrogen or mean yearly effluent concentration 4 mg/l) was carried out in 30 plants, serving 500,000 inhabitants. Denitrification (more than 60% nitrogen reduction) was achieved in 18 plants serving 173,000 inhabitants.

During the 1980s and 1990s the amounts of organic matter and nitrogen in the influent have been fairly constant while the amount of phosphorus has decreased by 20 % since 1990. This decrease is a result of the widespread use of phosphate-free detergents instead of detergents containing phosphate.

The performance of municipal wastewater treatment plants has continuously improved. By the year 1996 the average degree of organic matter (BOD_7) removal and phosphorus removal has risen to 93%. The reduction percentages are calculated including bypasses and overflows. These results, representing the normal functioning of Finnish wastewater treatment plants, are among the best in Europe and the whole world. However, because the average degree of nitrogen removal has remained at the level of only 30%, there still remains challenges enough for treatment specialists in the near future.

Nitrogen loads before and after treatment in municipal sewage works, 1971 – 1996.

These good achievements have resulted in a very substantial reduction of the environmental load caused by the municipal wastewaters. Since the early 1970s, the total load of organic matter (BOD) from public wastewater plants into lakes, rivers and sea areas has fallen by 82%, and the load of total phosphorus by 88%.

Goals in the 2000's

Membership of the European Union and other international and bilateral agreements have affected and will continue to affect the requirements for waste water treatment in Finland. All regulations of the Council Directive concerning urban waste water treatment have been incorporated in Finnish legislation. The Finnish Government Resolution on the Water Protection Targets to 2005 reflects these demands together with national goals that are set by requirements of recipient waters. All recipient waters in Finland are sensitive but the sensitivity has not been defined according to the nutrient.

Phosphorus is the main nutrient to cause eutrophication in the inland waters in Finland. According to Water Protection Targets to 2005 the total phosporus load from municipalities should be decreased by 35% compared to the mean level in 1991-1995. Thus, the mean effluent phosphorus concentration should be around 0.35 mg/l in 2005 and the average reduction efficiency about 95%. It is also recommended that biological phosphorus removal should be developed and promoted to reduce chemical usage. At least 50% nitrogen removal should be reached at all plants serving more than 10 000 PE in cases where nitrogen in the effluent contributes to euthrophication.

WATER SERVICES IN RURAL AREAS

Those not served by public water services live mainly in rural areas. In 1996, some 0.65 million people, i.e. 13% of the population, were not served by the public water supply. They were mainly using private shallow wells or bedrock boreholes for their water supplies. In rural areas there are also small water cooperatives distributing water to villages with several farms and houses but most wells and boreholes are used by one family.

Based on health criteria, the water from private wells is usually of fairly good quality. In some areas there are problems such as high concentrations of iron, manganese, fluoride, radon or arsenic. These problems arise mainly from geographical circumstances and location. However, poor structural condition of wells is one of the main reasons for occasional high bacteria and nitrate concentrations in private wells. Due to Finnish soil conditions, the quality of the water in private wells does not usually meet all the standards set for the technical and aesthetic quality of drinking water. Besides qualitative problems in private wells, there have been some occasional quantitative problems too.

Technological development and the provision of advice on site selection and the proper construction of wells have been some of the measures the water authorities have taken to improve the situtation. A government financial support system also exists.

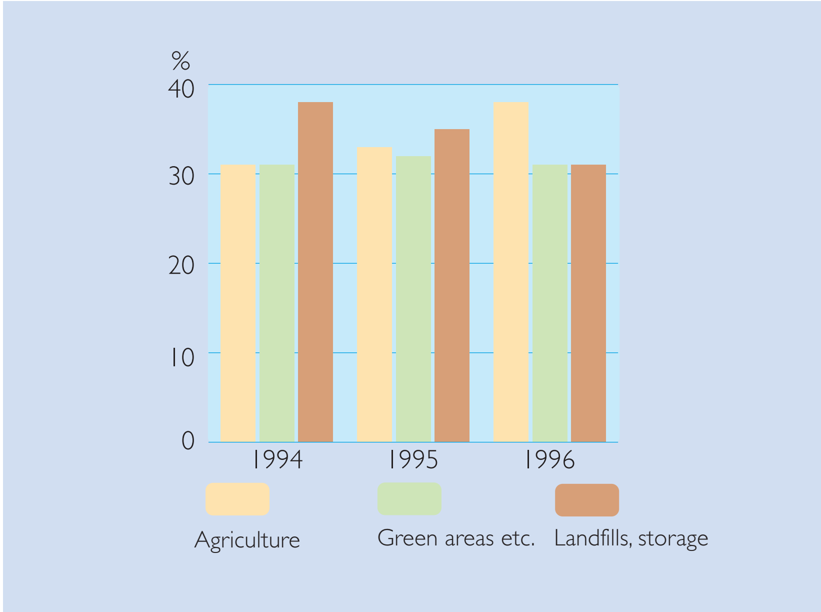
Buried sand filters are presently often used to treat wastewater from single houses.

In 1996, the number of people not connected to public sewer networks was 1.1 million, 22 % of the total population. The traditional on-site wastewater treatment method has been a two- or three-chamber septic tank, with no further treatment before discharge into a ditch or soil. At present the septic tank alone does not meet the requirements set for the wastewater treatment in rural areas. More advanced methods are required. Soil absorption systems, package wastewater treatment plants and holding tanks for collecting toilet wastewater are becoming common.

A feature typical to Finland is the abundance of holiday homes. The number of holiday homes has continuously increased and was 420 000 in 1996. Many of them are in use the year round. Most of the holiday homes, which are often situated close to the shorelines, are not connected to the public sewer and this may result in local pollution problems.

The significance of wastewater pollution from rural areas has grown as treatment of municipal wastewater has improved over the last decade. At present the phosphorus load to water bodies from the settlements with no public wastewater services is higher than the total phosphorus load from the settlements served by public sewerage and wastewater treatment.

According to the Water Protection Targets to 2005, loadings from scattered settlements should be considerably reduced. Organic matter load should be reduced by 60% and phosphorus load by 30% of the situation in the early 1990s. In order to achieve these goals, several legislative, administrative, informative and financial measures must be taken. Wastewaters from new or renovated houses should be treated by the best available technology and on-site wastewater treatment should be improved in 60 000 houses and in 50 000 holiday homes by the year 2005.



Utilization and disposal of municipal sewage sludge 1994 – 1996.

TREATMENT AND UTILIZATION OF SLUDGE

As a result of the increasing amount of wastewater collected and treated, the quantity of sludge produced in wastewater treatment plants was increasing until the end of the 1980s. Also more efficient water treatment processes with nutrient removal have resulted in the increasing amount of sludge. Throughout the 1990s the annual amount of sludge resulting from wastewater treatment plants has been about one million cubic metres, or about 150 000 tonnes of sludge expressed in dry solid matter. Wastewater treatment plants produce annually about 40 kg dry solid matter per person. Over the past 25 years the amount of sludge produced per person has doubled.

Potential health hazards and environmental damages and risks caused by sludge, can be prevented by treatment and appropriate utilization. Sludge is stabilized to prevent the spread of infectious disease and reduce problems of odour, and to improve utilization properties. Stabilization of sludge has increased in Finland. In 1996, more than 70% of sludge was stabilized. The most common stabilizing methods were anaerobic digestion and lime stabilization. However, lime stabilization has decreased over the last few years because of increased costs. Sludge composting is becoming increasingly popular. In 1996, almost 60% of the sludge was composted.

Sludge dewatering reduces sludge volume and environmental hazards arising from its final deposition. Sludge is dewatered in almost all wastewater treatment plants. The most common sludge dewatering methods are belt-pressing and centrifugation.

Over the past couple of decades major changes have taken place in the utilization of sludge. Utilization of sludge in agriculture became common in the 1980s. In the middle of the 1980s, about 50% of sludge was used as a fertilizer or for soil improvement. Since then the utilization of sludge in agriculture has decreased because of stricter regulations and negative attitudes of agricultural producers. In 1996, only about 30% of sludge was applied to agriculture.

Utilization of sludge as a topsoil medium or for soil improvement in various construction projects (parks, roadsides etc.) has continuously increased. In 1996, almost 40% of sludge was used for such beneficial purposes.

Over the last few years the amount of sludge disposed in sanitary landfills has decreased to some extent. In 1996, however, about 30% of sludge was taken to landfills or permanent storage sites, which is comparable with landfilling. In Finland, sludge is not incinerated and lakes, rivers or sea areas are not used for final disposal of sludge.

The most difficult problem in connection with sludge utilization has been considered to be accumulation of harmful substances, heavy metals in particular, in the sludge. However, concentrations of heavy metals in sludges from treatment plants have decreased significantly and continuously since the 1970s. The discharges of wastewater containing heavy metals have been reduced through the imposition of stricter requirements on industrial establishments, intensified control of waste management, and more appropriate management of hazardous wastes.

RESEARCH AND DEVELOPMENT

Research and development in the field of water services has a fairly long history in Finland. Several research institutions have traditionally concentrated on problems that have been important with respect to the domestic needs of water and sewage utilities. Later international cooperation also became more important. At present the main research institutions in this field are the Finnish Environment Institute, Geological Survey of Finland, National Public health Institute, Finnish Centre for Radiation and Nuclear Safety, Helsinki University of Technology, Tampere University of Technology, University of Oulu and Åbo Akademi University.

Earlier studies of the predecessors of the Finnish Environment Institute included assessment of the groundwater and surface water quality. By the late 1950s, a comprehensive study was carried out on the quality of drinking water abstracted from private wells. Also removal of iron and manganese from groundwater, production of artificial groundwater and several other issues related to water treatment have been studied.

Biological, chemical and physical processes for wastewater treatment have been studied and developed for Finnish conditions. FEI has a well equipped research station for technical-scale process research on wastewater treatment. The finding of solutions for rural water and wastewater treatment and management has also been a key issue. Most of the R&D-projects have been conducted in cooperation with municipal water and sewage works and universities.

Today the focus in the field of water treatment is on artificial groundwater production. FEI participates in the EU-project called Artificial Recharge of Groundwater together with research institutions from Denmark, Sweden, Belgium, Germany, the Netherlands and Spain. In the future, the development of technology for small water works will be one important research issue. Removal of some harmful substances in the groundwater, like radon, fluoride and arsenic, still call for continued research efforts. In addition, the development needs of the water works will also concentrate very much on the rehabilitation of networks and process equipment.

In 1997 the Technology Development Centre launched a three-year research program "Water Services 2001" with a total budget of 60 million FIM (10 MECU, 12 MUSD). The Finnish Water and Waste Water Works Association takes care of the coordinating the program. In the framework of this program the FEI is studying combined biological phosphorus and nitrogen removal from wastewater in cooperation with several sewage works. As the demand for phosphorus and nitrogen removal is tightened, more efficient treatment methods are needed.

In the framework of "Water Services 2001" FEI also has a project studying the eco-efficiency of water supply and wastewater treatment as well as a project developing onsite wastewater treatment methods and management systems for their construction, operation and maintenance.

Despite abundant water resources, water saving technology is also developed and tested in Finland. A dual piping system is in use in Ylöjärvi.

INTERNATIONAL COOPERATION AND EXPORT ACTIVITIES IN THE FIELD OF WATER SERVICES

International cooperation is today important in almost every sector of business, research and cultural life. In addition to the enterprises active in foreign trade, the national, regional and local authorities, water and sewage works, as well as R&D institutes, all participate in different kinds of international projects.

In 1991, the Ministry of the Environment launched what is a still strongly-proceeding program in Central and Eastern Europe, i.e. in the Baltic countries, Russia and Poland. The cooperation promotes and supports projects which aim to improve the state of the environment with both finance and other relevant means.The program focuses on investment projects, technical assistance and training in the fields of air and water pollution control and waste management. Protection of the Baltic Sea has been one of the main targets. Renovation of the sewers in St. Petersburg and construction of the wastewater treatment plants in Tallinn, Estonia and in Klaipeda, Lithuania are among the major recent investment projects. Many consulting, manufacturing and construction companies as well as the Finnish Environment Institute have been involved in projects financed partly through the Ministry of the Environment. Also some water and sewage works have been involved in the cooperation in the Baltic countries and in Russia through twinning and similar arrangements. For instance, Tallinn's water and sewage works are developed through transfer of technology and know-how between the cities of Helsinki and Tallinn. Also the Ministry of Agriculture and Forestry participates in the development of the water supply in Russian Karelia.

The Finnish Environment Institute has recently reorganized its international consulting activities. Early in 1997 an International Projects Unit was established and it offers a wide variety of environmental consulting services, involving water supply and sanitation. Most of the assignments are related to project identification, evaluation or supervision. FEI does not provide services like design and engineering.

Water supply and sanitation has traditionally been one of the key sectors of Finland's development cooperation. Several bilateral projects in African countries like Tanzania, Kenya, Ethiopia, Namibia, Mozambique, Zambia and Egypt and in the Far-East countries like Sri Lanka, Nepal and Vietnam have been supported through the official development aid of the Finnish Government.

Finnish construction companies have also carried out projects worldwide in the water supply and sanitation sector. In the 1990's new projects were implemented elsewhere, for instance in Estonia and other Baltic countries, Poland, Hungary, Russia, as well as in China. As to export activities of Finnish planning and consulting companies, water supply and sanitation has been one of their key sectors. Important market areas are the OECD-countries, the Eastern European countries and developing countries. In the field of water industry, plastic pipes, pumping technology, water and wastewater treatment equipment, as well as chemicals, have been among the main export items of material suppliers.

The long term development cooperation project in Beni Suef in Egypt started in 1993.

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