Types, numbers and performance of decentralized wastewater treatment plants in the EU-15

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Types, numbers and performance of decentralized sewage treatment plants in the EU-15

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CONTENTS

1. Introduction

1.1 Background and objectives

The ERASM project team has asked Lettinga Associates Foundation (LeAF) to offer its services within a research project that investigates the effectiveness of decentralized sewage treatment plants in removing surfactants and detergents. Decentralized sewage treatment plants are defined here as systems serving 1 – 100 persons (or population equivalents, p.e.). The objectives of this study are the following:

1. Identification of the different types of (aerobic) small wastewater treatment systems and septic tanks used in the “old” fifteen EU countries (EU-15). The EU-15 include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.
2. Compilation of the number of different types of (aerobic) small wastewater treatment systems used in the EU-15 countries.
3. Compilation of the treatment efficiency specifications (especially BOD removal and nitrification) of these systems.

The ERASM project group has the overall goal to assess to which extent (intermediate degradation products of) surfactants and detergents might end up in the environment (water, soil) through the effluents of small wastewater treatment plants. The aim of this study is to provide an overview of the current situation with respect to small wastewater treatment systems and identify the most applied systems in the EU-15. This information will be guiding for a follow-up that will probably consist of an experimental study into the removal of surfactants and detergents in one or more small wastewater treatment plants.

This study has focused on the EU-15 member states. However, during the course of the project the ERASM project team considered it important to also include some statistical information on the 10 new member states that entered the European Union on 1 May 2004. Therefore, chapter 3 contains some information on the state of wastewater treatment in the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia.

1.2 Approach

The first two objectives of the study were tackled by a combination of literature review, internet searches, analysis of statistical data of the EU-15 countries and inquiries with specialists in the various EU countries. Where sufficient data were unavailable, estimations were made based on expert judgment.

After the number and types of onsite wastewater treatment systems were compiled, the identified systems were classified according the type of technology applied and the treatment category for which they are certified. Based on the treatment principles and the effluent requirements the level of BOD removal and nitrification for the various categories were assessed.

1.3 Outline of this report

Part A of this report contains the inventory of onsite wastewater treatment systems and septic tanks used in the EU-15. Part B of the report describes the various types and performances of onsite wastewater treatment systems and septic tanks used in the EU-15.

2. EU Legislation and statistical data referring to small wastewater treatment plants

2.1 Introduction

This chapter provides a general introduction on the situation with respect to small wastewater treatment plants from EU perspective. The chapter introduces the legislation that applies at European level and provides data on the wastewater treatment situation and the population density in Europe.

Paragraph 2.2 discusses the Urban Waste Water Treatment Directive and its implications for the establishment of small wastewater treatment plants. Paragraph 2.3 provides statistical information on wastewater treatment in the European Union, using data from Eurostat and the European Water Association, while 2.4 provides information on the population density in Europe.

2.2 European legislation for small wastewater treatment plants

2.2.1 The Urban Waste Water Treatment Directive

The European urban wastewater legislation is captured in the “Urban Waste Water Treatment Directive” (UWWTD; 91/271/EEC), of which the entire text can be found in Appendix A of this report. The European Commission describes the objectives of the Directive as follows (excerpt from E.C. website):

- provide prior regulation or specific authorization for all discharges of urban waste water and industrial waste water from the particular sectors mentioned in the Directive, as well as for all discharges of industrial waste water into urban waste water systems;
- provide urban waste water collecting systems (sewerage) and treatment plants for all agglomerations above 2.000 population equivalents (widely used measurement unit for the organic pollution of waste water equalling to the average pollution load of one person per day).
- ensure that by 31/12/2000 the industrial waste water from the mentioned sectors shall before discharge respect the established conditions for all discharges from plants representing 4.000 population equivalent or more;
- provide before 31/12/1998 general rules or registration or authorization for the sustainable disposal of sludge arising from waste water treatment and, by the same date, to phase out any dumping or discharge of sewage sludge into surface waters;
- ensure that the urban waste water discharges and their effects are monitored;
- publish situation reports every two years and establish implementation programmes.

The different countries have to make an inventory of sensitive and less sensitive areas, according to criteria provided in the UWWTD. Depending on this classification the areas are treated differently, and different deadlines apply for implementation (Table 1).

Table 1. Deadlines for Directive 91/271/EEC, last updated 21-01-2004 (European Commission).

Area	Population equivalents (p.e.)				
	0-2000	2000-10.000	10.000-15.000	15.000-150.000	+150.000
Sensitive areas	if collection 31/12/05 appropriate treatment	collection 31/12/05 secondary* treatment	collection 31/12/98 more advanced treatment	collection 31/12/98 more advanced treatment	collection 31/12/98 more advanced treatment
Normal areas	if collection 31/12/05 appropriate treatment	collection 31/12/05 secondary* treatment	collection 31/12/05 secondary treatment	collection 31/12/00 secondary treatment	collection 31/12/00 secondary treatment
Less sensitive areas (coastal waters)	if collection 31/12/05 appropriate treatment	collection 31/12/05 appropriate treatment	collection 31/12/05 primary or secondary treatment	Collection 31/12/00 primary or secondary treatment	collection 31/12/00 primary (exceptional) or secondary treatment

* appropriate treatment if discharge to coastal waters

2.2.2 The UWWTD and small wastewater treatment plants

Article 7 of the Urban Waste Water Treatment Directive refers especially to agglomerations of less than 2000 population equivalents (excerpt from the directive):

Article 7

Member States shall ensure that, by 31 December 2005, urban waste water entering collecting systems shall before discharge be subject to appropriate treatment as defined in Article 2 (9) in the following cases:

- for discharges to fresh-water and estuaries from agglomerations of less than 2 000 p.e.,

…

Article 2 (9)

'appropriate treatment' means treatment of urban waste water by any process and/or disposal system which after discharge allows the receiving waters to meet the relevant quality objectives and the relevant provisions of this and other Community Directives;

The relevant quality objectives of receiving waters within this directive are based on the diversion in sensitive and non-sensitive waters. For non-sensitive waters there is no quality objective. In addition there are also no treatment requirements defined for agglomerations of less than 2000 p.e. For sensitive receiving waters the requirements of Table 2 apply. This table does not define effluent requirements for small treatment plants, but the minimum percentage of reduction of P and N for a region. It is up to the member states to translate these reduction targets into local regulations for small-scale wastewater treatment plants. Especially in rural regions (like Finland and Sweden) the reduction percentages play an important role in the standards that have been set by individual member states.

Table 2. Requirements for discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication as identified in Annex II.A(a). One or both parameters may be applied depending on the local situation. The values for concentration or for the percentage of reduction shall apply (source: Directive 98/15/EEC amending directive 91/271/EEC).

Parameters	Concentration	Minimum percentage of reduction (1)	Reference method of measurement
Total phosphorus	2 mg/l P (10 000 - 100 000 p. e.) 1 mg/l P (more than 100 000 p. e.)	80	Molecular absorption spectrophotometry
Total nitrogen (2)	15 mg/l N (10 000 - 100 000 p. e.) 10 mg/l N (more than 100 000 p. e.) (3)	70-80	Molecular absorption spectrophotometry

(1) Reduction in relation to the load of the influent.

(2) Total nitrogen means: the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate (NO_3)-nitrogen and nitrite (NO_2)-nitrogen.

(3) These values for concentration are annual means as referred to in Annex I, paragraph D.4(c). However, the requirements for nitrogen may be checked using daily averages when it is proved, in accordance with Annex I, paragraph D.1, that the same level of protection is obtained. In this case, the daily average must not exceed 20 mg/l of total nitrogen for all the samples when the temperature from the effluent in the biological reactor is superior or equal to 12°C. The conditions concerning temperature could be replaced by a limitation on the time of operation to take account of regional climatic conditions.

2.2.3 Identification of sensitive and less sensitive areas

The EU member states have to make an inventory of their sensitive and less sensitive areas, according to the criteria provided in the Urban Waste Water Treatment Directive.

The sensitive areas must be designated according to one or more of the following criteria:

- water bodies which are found to be eutrophic (eutrophication is an enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life) or which in the near future may become eutrophic if protecting action is not taken;
- surface freshwaters intended for the abstraction of drinking waters and which could contain more than 50 mg/l of nitrates if action is not taken;
- areas where further treatment is necessary to fulfil other Council Directives.
- The list of sensitive and less sensitive areas must be reviewed every four years.

In accordance with Article 5(8) of the Directive, a Member State does not have to identify sensitive areas if it applies more stringent (tertiary) treatment over all its territory. Five Member States have decided to apply more stringent treatment in this way: Denmark, Luxembourg, the Netherlands, Finland and Austria. Belgium (since 2001) and Sweden do not apply Article 5(8), but have identified their entire territory as a sensitive area. Eight other Member States - Germany, Spain, France, Greece, Ireland, Italy, Portugal and the United Kingdom - have identified certain water bodies in their territory as sensitive areas.

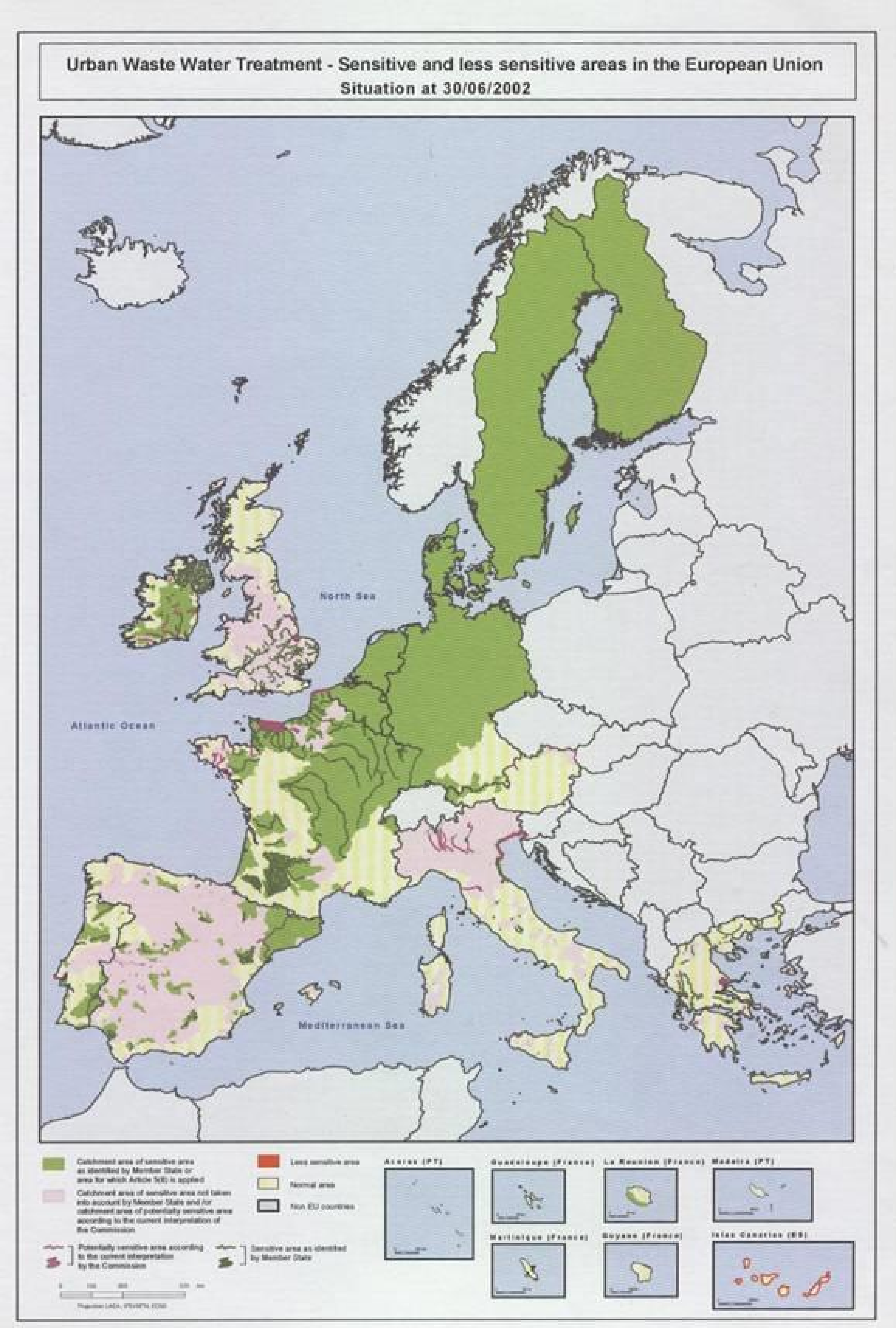


Figure 1. Sensitive and less sensitive areas in the European Union Situation at 3/06/2002 (European Commission, 2004)

2.2.4 Conclusion

The Urban Waste Water Treatment Directive does not provide minimal effluent standards for treatment plants with a capacity below 2000 population equivalents. For non-sensitive areas the Directive does not define any treatment requirements (not even a septic tank). For sensitive areas the situation depends on the local situation. For a certain sensitive area the reduction percentages for total nitrogen and total phosphorus are 80% and 70-80% respectively. Depending on the percentage of the population that is connected to sewer systems and treatment plants > 2000 population equivalents less or more stringent requirements will have to be set of small wastewater treatment plants. Most individual EU member states, have implemented regulations for small wastewater treatment plants. In the framework of this study these will be used as a starting point.

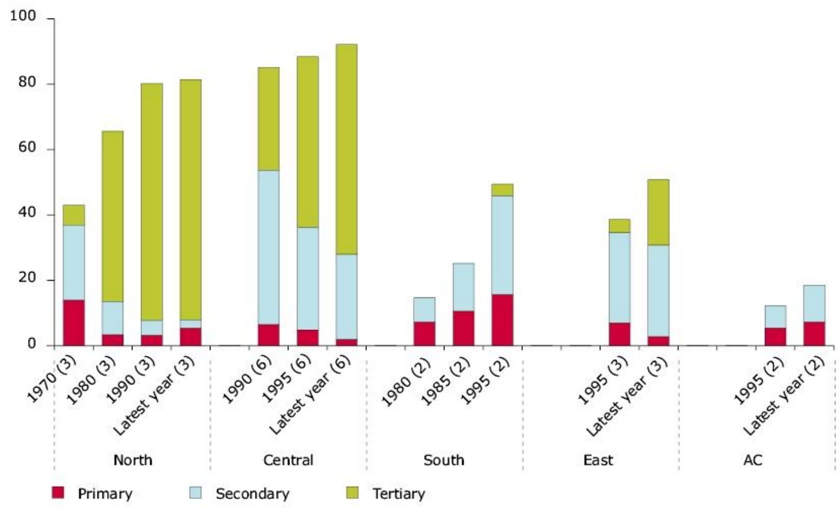
2.3 State of wastewater treatment in the EU-15

Chapter 3 contains an inventory investigation into the number of different types of (aerobic) onsite wastewater treatment systems and septic tanks in the EU-15. Prior to this investigation the data that are available through various European sources are presented.

In the 2005 environment outlook report of the European Environment Agency it is stated that at that time around 90% of the population in northwest Europe was connected to sewers and treatment systems. For the southern European members of the EU-15 the figure lies between 50% and 80%. Generally the treatment systems for urban wastewater are divided in three categories:

- Primary treatment: Removal of mainly solids, usually by mechanical or physical means
- Secondary treatment: Biological treatment removing or neutralizing microbiological contamination and oxygen-consuming organic material.
- Tertiary treatment: The most advanced treatment, which removes inorganic compounds and nutrients.

Not only in the percentages of connection to sewerage and treatment plants there are differences between the regions in Europe, but also in the level. While more than 70% of wastewater in Austria, Denmark, Finland, Germany, the Netherlands and Sweden undergoes tertiary treatment, in southern Europe this figure is only around 10%. Figure 2 shows the increase in urban wastewater treatment in the European Union and the differences between different regions, by comparing the percentages of the national population that are connected to waste water treatment plants. More detailed information per country is provided in Figure 3.



Note: Only countries with data from all periods are included, number of countries in parentheses. North: Norway, Sweden, Finland. Central: Austria, Denmark, England and Wales, the Netherlands, Germany, Switzerland. South: Greece, Spain. East: Estonia, Hungary and Poland. AC: Bulgaria and Turkey. (EEA)

Figure 2. Changes in wastewater treatment in regions of Europe - National population connected to waste water treatment plants (%).

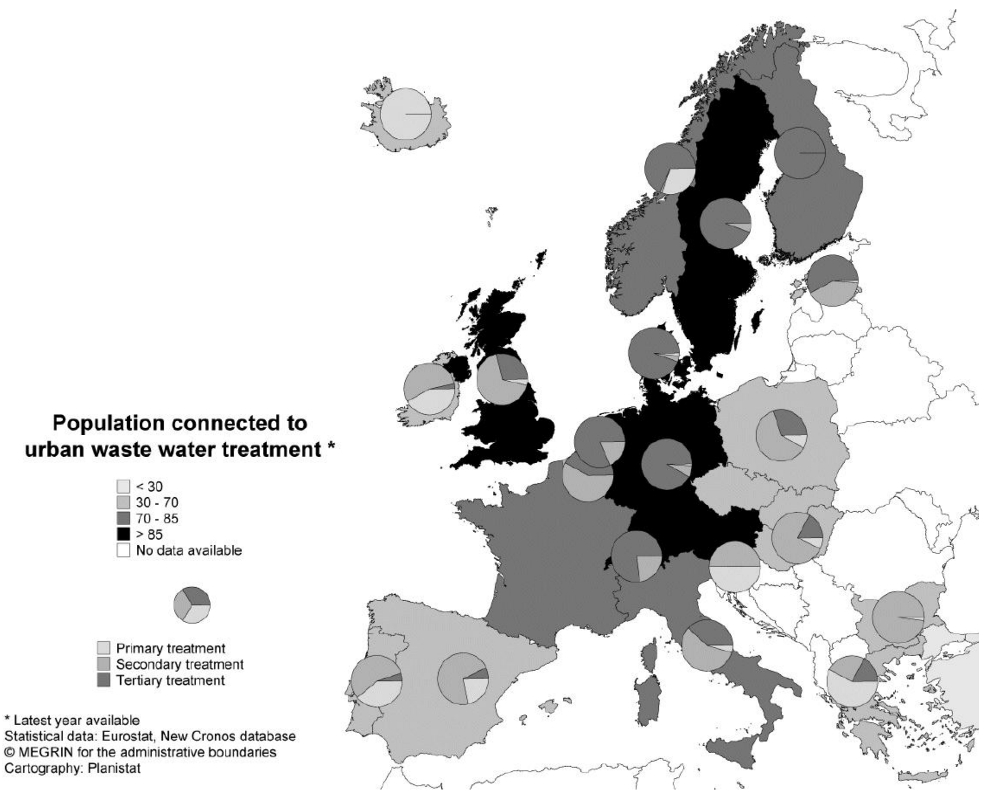


Figure 3. Population connected to wastewater treatment, information latest year available (Wieland 2003).

Through the last decades the percentage of the European population connected to sewers and to wastewater treatment plants has increased steadily. The European Union statistics office Eurostat has data available on this topic for different countries, and although the numbers are far from complete, the trend is clearly visible. Table 3 and Figure 4 show the available data for the EU-15 countries gathered by Eurostat.

Table 3. Percentage of population of the EU-15 countries that are connected to sewer systems and/or treatment systems according to Eurostat (source: Eurostat 2006)

Country	1970			1980			1990			1998			2001			2004		
	Sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.
Belgium	-			-	23		-			82	46		-			-		
Denmark	88	55		88			86	99	13	89	100	11	-			-		
Germany	-			-			-			93	98		-			95	93	
Finland	53	51		69	94		76	100		79	99		81	100		-		
France	-			-			-		11	79	97		-			-		
Greece					1													
Ireland	-			-	11		66	67		-			-			-		
Italy	-	14		-			-			-	75		-			-		
Netherlands	44	100		86	100		96	100		98	100		98	100		99	100	
Norway	85	25		80	43		77	74	23	80	91	20	80	91	20	-		
Austria	-	17		-	38		72	100		82		19	86	100	14	-		
Portugal	-			35	6		55	38		82		5	-			-		
Spain					18			40										
Sweden	100	63		100	82		-	94		93	100		86	100		-		
Switzerland	-	35		-	73		-	90		96	100		96	100		-		

sew. = % of population connected to sewer systems, irrespective whether or not treatment follows
wwtp = % of population connected to sewer systems which includes subsequent wastewater treatment
indiv. = % of population connected to small-scale (individual) wastewater collection and treatment systems

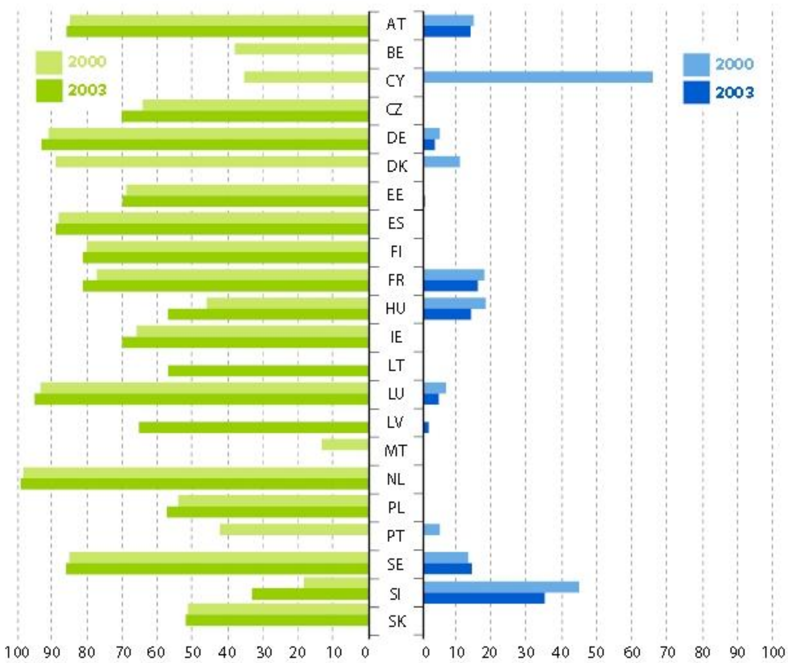


Figure 4. Percentage of population connected to urban wastewater treatment systems (left), or to a collecting system with independent treatment (right). 2000 figures refer to 1998 for Belgium, France, Denmark, Germany, Portugal; and 1999 for Ireland, and Luxembourg. 2002 figures refer to 2001 for Germany and France and 2003 for Luxembourg (European Commission 2005).

Table 4 presents the statistics given in the 2005 yearbook of the European Water Association. These data are considered more accurate than the data that are shown in Table 3. It should however be noticed that only 10 of the EU-15 countries are EWA members. The following countries are lacking in his overview: Denmark, Greece, Ireland, Italy and Sweden.

Table 4. Percentage of population that are connected to sewer systems and treatment systems in the ten EU-15 countries that are members of the European Water Association (EWA 2005)

	data for year	Waste-water quantity $(10^6\ m^3/y)$	% total population connected		Wastewater treatment plants	% of annual wastewater quantity treated with		
			public sewer systems	public treatment plants		primary treatment	primary and secondary	primary, secondary and tertiary
Austria	2001	1068	86.6	86.6		< 1	6.7	93.3
Belgium (Flanders)			84.6	55.1		0	1.1	54
Belgium (Wallonia)		261	73			0	28.1	10.8
Belgium (Brussels)		79	90	20		0	20	0
Finland	2004	500	81	81	450	0	10	90
France	2000	16,3	93	87.5	15435	[1] 15	70	[1] 15
Germany	2001	10473	95	93		0.2	5.1	94.7
Great Britain	2000		94	94		1.6	68	30
Luxemburg	2003	65	99	94		4	74	22
Netherlands	2002	1346,6	98	98	406	0	19,8	80,2
Portugal	2002	458	71 [a]	50	1312 [a]	19	18	15
Spain			86	83		24,8	70	4

[a] numbers are for population in cities only

2.4 Population density in Europe

As decentralized treatment systems are usually implemented in sparsely populated areas, it is important to know which areas these are. Figure 5 is a map of Europe indicating the sparsely populated areas, clearly showing the uneven distribution of these areas.

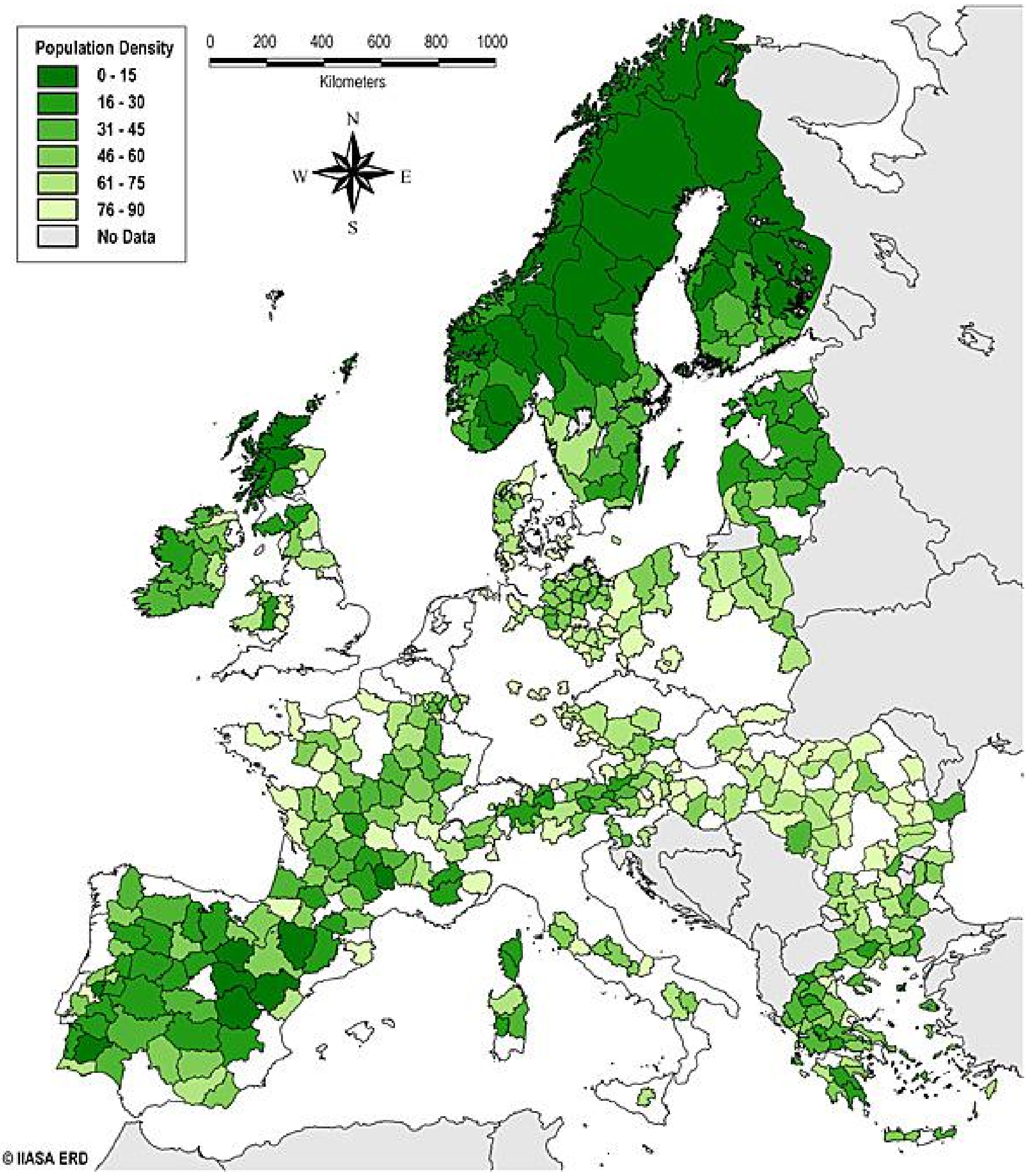


Figure 5. Sparsely populated areas of Europe (IIASA ERD project).

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EEA European Environment Agency (2005) The European environment - State and outlook 2005. Copenhagen

EWA European Water Association (2005) Yearbook 2005, http://www.ewaonline.de

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3. Country per country survey (EU-15)

3.1 Introduction

In the following pages, a survey on the situation in the EU-15 countries is presented as far as the use of on-site sewage treatment systems is concerned. Information about the legal and institutional framework is provided to depict the similarities, differences, and complexity surrounding the local application of European Directives. For some countries, conclusive data on the types and number of on-line sewage treatment systems is either not available or very difficult to find. Most of the figures found are based on rough estimations based on the people living in cities and relatively big agglomerations, who are generally assumed to be connected to a sewerage system. The "remaining" population is then assumed to have some type of decentralized sewage treatment system, mostly septic tanks.

3.2 Austria

Area: 83,859 km^2
Population (1,000): 8,140.1 inhabitants
Population density:
Capital: Vienna
Language: German
Currency: Euro €
GDP at market prices: € 237,038.6 million
GDP per inhabitant in PPS (purchasing power standards): € 27,300
GDP growth Rate: 2.4%
Inflation rate: 2.0%
Unemployment rate: 4.8%
Government debt/GDP: 65.2%
Public balance (government deficit or surplus/GDP): -1.3%
(Eurostat data for 2004)

Framework

According to the Austrian Water Law, the "Wasserrechtsgesetz 1959" (WRG 1959), a permit is needed for the discharge of (treated) wastewater into a receiving water. The discharge is judged by the goals of the WRG 1959. The protection of the waters from damage through discharges is based on two principles:

- The quality of the discharged water must at least comply with the emission standards set by law (emission principle).
- Additionally, the quality of the receiving water may not be worse than the desired surface water quality, which in the future will be determined by emission standards (immission principle).

For existing wastewater treatment plants that are not officially allowed by the water laws and treat a load of maximum 10 p.e. a transition phase exists: these installation will be concerned to be legal when they existed at the moment the 1990 WRG amendment came into force (01-07-1990), and when it can be proven that they have been functioning and have been maintained according to the rules. (Land Salzburg 2006).

In Austria the norms for the application, size, building and usage of individual treatment plants are specified in ÖNORM B 2502-1: 2001 01 01: N "Kleinkläranlagen (Hauskläranlagen) für Anlagen bis 50 Einwohnerwerte - Anwendung, Bemessung, Bau und Betrieb". Indications for maintenance and monitoring given in ÖNORM B 2502-1 are (Extract from ÖNORM B 2502-1):

- Maintenance of the system should comprise all actions that ensure its lasting functioning and the demanded treatment efficiency. Only expert personnel can carry it out. When no own specialised staff is available, a maintenance contract should be taken.
- Daily check: verify if system is working
- Weekly check: Reading of the operating hours counter and other indicating devices, and entering the data in the operating book. Checking the air inflow in the aeration tank.
- Monthly: determine the sludge volume in the aeration tank, perform a visual check of the effluent quality (turbidity, colour, sludge loss), checking the NH_4-N concentration by means of a testing strip.
- Yearly: at least once a year the effluent should be analysed for NH_4-N and one of the sum parameters BOD_5, COD or TOC. The sample to be analysed should be non-settled and homogenized. When the NH_4-N level is below 5 mg/l, the other parameters are considered to be complying with the limit, without determining them.

The norm does not really specify binding discharge limits, but states that when the wastewater is suitable and the maintenance is done according to the rules, it should be possible to obtain the effluent characteristics listed in Table 5 (Lebensministerium 2004).

Table 5. Reachable effluent quality for individual treatment systems (Lebensministerium 2004).

Parameter	Concentration
Settleable matter	0,3 ml/l
BOD_5	25 mg/l
COD	90 mg/l
TOC	30 mg/l
NH_4-N	10 mg/l (at temperatures >12°C)
pH	6,5 - 8,5

Numbers and types of onsite treatment systems in Austria

In Austria the wastewater of 82.4% of municipalities (1943 of 2359) is collected in sewers and treated in WWTPs with a design load of ≥ 2.000 p.e. The wastewater of all other communities is either treated in smaller municipal plants (51 – 1999 p.e.), individual treatment plants (≤ 50 p.e.) or in septic tanks. The municipal treatment plants, 1495 in total, treat the wastewater of 86% of the Austrian population (6.934.300 of 8.065.465 inhabitants), leaving 14 % of the population to be served by individual treatment plants.

There will remain households, mostly in rural areas, for which the benefit for water and groundwater protection is not worth the effort to connect them. Here decentralized systems such as individual treatment systems will be used, such as activated sludge systems, biological filters, rotating biological contactors and filtration systems. With the mentioned individual treatment systems suspended matter and soluble biodegradable matter can be removed extensively, but nitrogen and phosphorous removal is limited. If the treated wastewater is to be discharged into sensitive receiving water (e.g. with low flow, falling dry periodically, previous stress, etc.) or underground flows (subterranean drainage devices or soakage pits) the wastewater treatment needs to comply with stricter demands: very low effluent concentrations, levelling of the flow, reduction of nitrogen and phosphorous and a reduction in the germination number (Land Salzburg 2006b).

Table 6 provides more information on the development and state of wastewater treatment in Austria (BMLFUW 2003). The percentage of the population that are served with small wastewater treatment systems is 14% or 1,129,165 people.

All small treatment plants need to be regularly checked, maintained and monitored. The owner should do the checking of the installation, whereas the maintenance should be carried out by experts, up to four times per year. Depending on the size and system type the effluent characteristics should be analysed more or less frequently (Land Salzburg 2006b). In the end of 2003 a proposal for the evaluation of individual treatment plants was made, in which also effluent limits were proposed that may not be exceeded when the effluent is discharged in to receiving water or into the soil. The proposed values are the same as mentioned in Table 5 (Schaber 2003).

Table 6. Development of connection to wastewater treatment in Austria (BMLFUW 2003).

	1971	1981	1991	1995	1998	2000	2001
Inhabitants	7.491.526	7.533.045	7.808.097	7.907.896	8.038.200	8.106.985	8.065.465
Public sewer with connection to municipal WWTP ^{3} 50 p.e.	47,9%	57,9%	71%	75,7%	81,5%	85,4%	86,0%
Individual treatment plants	16,4%	16,1%	9,8%	8,3%	6,5%	14,6%	14,0%
Septic tanks	28,5%	20,3%	17,8%	15,1%	11,4%		
Other treatment	7,2%	5,7%	1,5%	0,9%	0,6%		

References

BMLFUW Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2003) Kommunale Abwasserrichtlinie der EU - 91/271/EWG Österreichischer Bericht 2003

Extract from ÖNORM B 2502-1, http://gu-international.com/constantflow/mean/auszug.html

Land Salzburg (2006) Abwasserentsorgung im ländlichen Raum - Zusammenfassung der Rechtsgrundlagen, Land Salzburg, vertreten durch Abteilung 1: Wasserrecht, Bau und Feuerpolizeirecht, Energierecht, Strassenrecht. http://www.salzburg.gv.at/pdf-60-info-aw-abwasserentsorgung-laendlicher-raum.pdf (accessed March 2006).

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3.3 Belgium

Area: 30,518 km^2
Population (1,000): 10,396.4 inhabitants
Population density: 341 /km^2
Capital: Brussels
Language: French (40%), Dutch (60%), German
Currency: Euro €
GDP at market prices: € 283,752.0 million
GDP per inhabitant in PPS (purchasing power standards): € 26,500
GDP growth rate: 2.9%
Inflation rate: 1.9%
Unemployment rate: 7.8%
Government debt/GDP: 95.6%
Public balance (government deficit or surplus/GDP): +0.1%
(Eurostat data for 2004)

Legal and institutional framework in Flanders

The environmental legislation in Belgium is not a national affair, but the three regions (Flanders, Wallonia, and Brussels) have each their own legislation. A large part of the Brussels-Capital Region, which has around 1 million inhabitants, is not connected to a sewage treatment system and the new treatment plant won´t be ready until 2007 (http://www.aquiris.be). In 2001 90% of the Belgian population was connected to a sewer system and 47% to a public wastewater treatment plant. In the Flemish region, the government, the municipalities, and the households are all responsible for sewage treatment. Owners of homes that for technical or financial reasons can not be connected to a centralized treatment have to make their own arrangements. Current law divides Flanders in four treatment regions:

- Zone A: with sewers and connected to a sewage treatment plant
- Zone B: with sewers and connection to a sewage treatment plant has been planned
- Zone C: with sewers and not connected to a sewage treatment plant (so discharge to canal or surface water)
- Area without sewers

Citizens are obliged to connect to the sewer when present, at their own cost. Municipalities should check whether their inhabitants comply with this rule or not. People in zone C or in areas without sewerage are obliged by the Flemish environmental law to provide for their own wastewater treatment. The degree of required treatment is higher for new discharges than for existing discharges. A discharge in zone C is classified as new when started to exist after August 1st 1995, in the areas without sewers this date is March 1st 1993. In zone C the wastewater should be treated with a so-called IBA-system, a system for the individual treatment of wastewater (*Individuele Behandeling van Afvalwater*), built according to a code for good practice. If treatment takes place correctly, the owner can get a tax exemption for either the tax on surface water contamination (*heffing op oppervlaktewaterverontreiniging*), or the sanitation tax (*saneringsbijdrage*). For now, in areas without sewers, a good-working septic tank or similar system is enough to comply with the law. People treating their wastewater only in a septic tank do not qualify for this exemption. Many municipalities employ a subsidy system for installing IBA-systems, sometimes topped up by a subsidy of the Flemish government, or the provincial government. The IBA-effluent must comply with the criteria in Table 7.

Table 7. Flemish discharge norms for IBA-systems.

	Unit	Value
pH	-	6.5 – 9
BOD_5	mg O_2/L	25 – 50 (50 for families)
Settleable solids	mg/L	0.5
Suspended solids	mg/L	60
CCl_4 extractable compounds	mg/L	3
Hazardous compounds	-	Forbidden
Oil & grease	-	Forbidden
Pathogens	-	limited amounts

Numbers and types of onsite treatment systems in Flanders

In 2005 Flanders had an overall sewer connection percentage of 87% and an overall percentage of connection to wastewater treatment of 64%. The municipalities with the highest sewer connection percentage reach 100%, whereas the lowest connection percentage is 35%. For connection to a wastewater treatment these numbers are 100% and 0% respectively. As the people that are subject to individual wastewater treatment schemes can apply for a tax exemption, the number of granted exemptions (Table 8) is an indication of the progress made with the installation of the systems.

Table 8. Exemptions granted for tax by the Flemish provinces from 1998 to 2002.

Year	Province					
	Antwerpen	Limburg	Oost-Vlaanderen	Vlaams-Brabant	West-Vlaanderen	Total
1998	56	1	56	2	4	119
1999	79	5	37	36	16	173
2000	91	7	116	37	19	270
2001	188	53	182	34	12	469
2002	231	71	234	47	13	596

The number of exemptions has risen, but there are strong regional differences. Despite the increase in number of IBA-systems, it is still a fraction of what should be installed according to law. Probably the strict laws regarding the tax exemption play a role in this.

Legal and institutional framework in Wallonia

Wallonia has revised its so-called Sub-basin Area Wastewater Treatment Plans (PASHs in French), which were municipal plans that provided for the construction in 2001 of more than 1,200 collective treatment plants in the Walloon Region. The plans faced problems and many of the treatment plants had not been built. The new sub-basin plans give a specification of the urban wastewater treatment scheme (collective, individual, or transitional) of each area zoned for urbanisation in the Walloon Region. Of the population, 80% is located in agglomerations of at least 2,000 PE and close to 12% of the population (130,000 dwellings or 400,000 inhabitants) are subject to individual wastewater treatment schemes. According to the area plans, two-thirds of the latter are in areas zoned for urbanization. In these areas, installing an individual sewage treatment system is compulsory for all new dwellings, whilst old dwellings have until 1 January 2010 to comply with this obligation. Figure 6 shows how the wastewater treatment situation will look in the future if the wastewater treatment plans are carried out as planned.

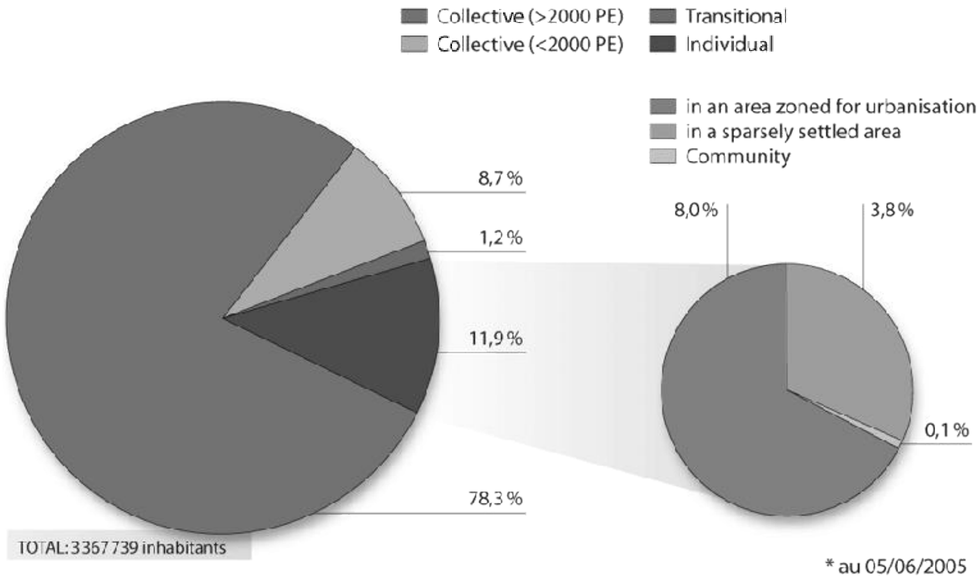

Figure 6. Planned wastewater treatment scheme for Wallonia

In the PASHs a subsidy system was set up: people who would install such a system at their own expense would be exempted from paying for sewage treatment and sewage tax (€0.4/m³ of piped water consumption), subject to certain conditions and they would also be eligible for a premium from the Walloon Region. The application rate for individual sewage treatment premiums had risen exponentially, but as the budget for subsidies only allowed for the payment of around 800 premiums per year, it was unlikely that the deadline of 1 January 2010 would be met. To encourage quality individual sewage treatment new regulations went into effect on 1 January 2004. They provide for carrying out periodic inspections of the treatment systems, reducing the premium from €1,500 to €500 for systems that comply but are not approved, and increasing the premium for joint sewage treatment initiated by the municipality. These new measures stimulate more and more people to install approved systems, but in the case of new houses the owners tend to install cheaper non certified treatment systems, as they are not eligible for the premium. Furthermore, only a few systems for treating wastewater of small communities (about 50 p.e.) are certified.

Numbers and types of onsite treatment systems in Wallonia

At the end of 1999, 38% of wastewater in the Walloon region could be treated. By January 1st 2005, there were 137 treatment plants with capacities of 2,000 p.e. that could treat a pollution load of 2,500,000 p.e., or about 60% of the nominal capacity that the region must install to comply with Directive 91/271/EEC. By the end of 2005 it was expected to have only a remainder of around 11% (473,000 p.e.) of the target to meet. As the people that are subject to individual wastewater treatment schemes can apply for a premium of the government, the number of accepted applications for this premium (Figure 7) is an indication of the progress made with the installation of the systems.

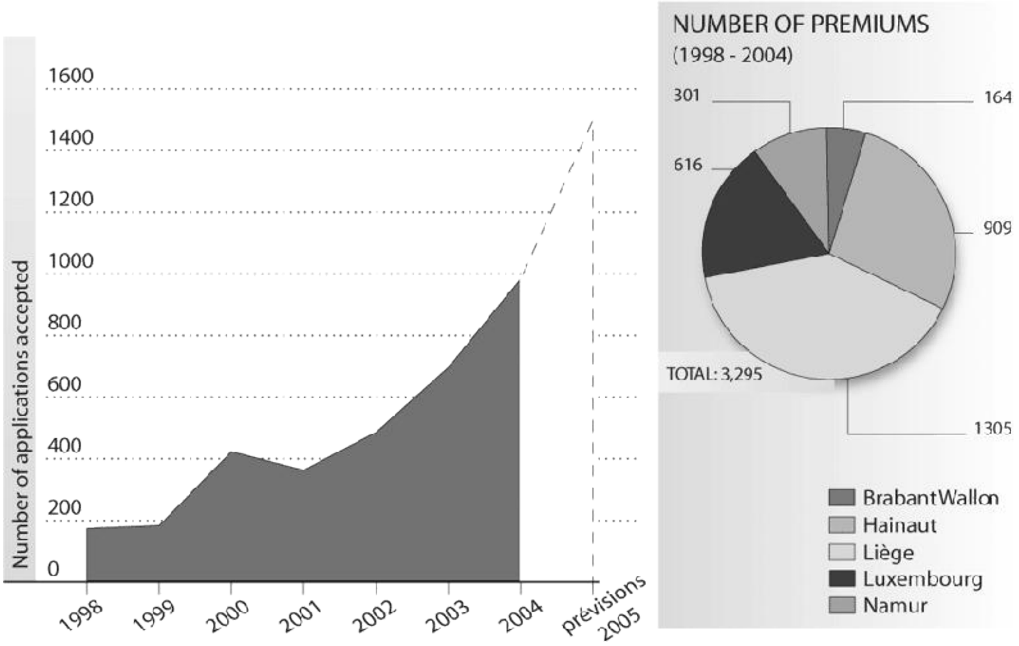

Figure 7. Number of accepted premiums for individual sewage treatment systems

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Statbel - Het Leefmilieuportaal (http://statbel.fgov.be/port/env_nl.asp)

Vlaams Reglement betreffende de Milieuvergunning (VLAREM Art. 4.2.7.1.1.)

Waterloket Vlaanderen (http://www.waterloketvlaanderen.be)

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3.4 Denmark

Area: 43,094 km^2
Population (1,000): 5,397.6 inhabitants
Population density: 125 /km^2
Capital: Copenhagen
Language: Danish
Currency: Danish Kroner
GDP at market prices: € 196,299.7 million
GDP per inhabitant in PPS (purchasing power standards): € 27,400
GDP growth rate: 2.4%
Inflation rate: 0.9%
Unemployment rate: 5.4%
Government debt/GDP: 42.7%
Public balance (government deficit or surplus/GDP): +2.8%
(Eurostat data for 2004)

Legal framework

The Danish overall regulation of wastewater management is embodied in the Environmental Protection Act (Consolidated Act No. 698 of 22 September 1998 as amended), especially in parts 3 and 4. These parts of the Act from the main legal framework for Statutory Order No. 501 of 21 June 1999 on the licensing of waste water discharges, which lays down specific rules for the administrative procedures to be followed by regional and local authorities in these matters. This Statutory order is also called the 'Waste Water Management Order' and contains (like its predecessor) the provisions for implementation of the UWWTD and the Council Directive 80/68 on the protection of ground water against pollution by certain dangerous substances.

Under the first Environmental Protection Act local authorities were required to prepare an overall plan for the disposal of wastewater within individual municipalities, and all Danish municipalities complied with this requisite. In the future all that is needed is basically the updating of the existing plans, including updating catchment area boundaries and preparing timetables. These plans have the following characteristics:
- the plans aim to provide an overview of existing and planned procedures for wastewater management within municipalities,
- the plans must highlight the environmental impact of these procedures and their financial consequences for the public wastewater service.
- the plans form the legal basis for connecting existing and new properties to the public collecting system.

Legislation requires all Danish wastewater to be collected and treated, including wastewater generated at individual houses in rural areas. In 2001 the Danish effluent values and the requested national coverage are stricter than the demands of the EU directives. When buildings are situated in a public sewer catchments area they are required to connect to that sewer, unless the municipality accepts local discharges. This acceptance of local discharges does not mean that the water can be discharged without treatment; it will be subject to Statutory Order no. 500 (1999) on small treatment plants of 5 - 30 p.e. The scope of the order is (citation):

1 - (1). This Order lays down the rules and regulations for a type approval scheme for small wastewater treatment plants with a nominal capacity of between 5 and 30 person equivalents (PE) which as regards quality are tested for inflow of wastewater the composition of which must not differ in respect of water volume or composition from what is typically present in domestic wastewater.
1 - (2). This Order lays down quality requirements as to purification, structural design, materials and functions as well as requirements as to testing, markings, control, and maintenance.

2 - (1). Type-approved small wastewater treatment plants encompassed by this Order have not been dimensioned for inflow of surface water from paved areas and drainage water.
2 - (2). In the event surface water, drainage water or other wastewater with a composition differing from domestic wastewater is inflowing to the plant, it must have been especially dimensioned for this.

In Statutory Order no. 500 four treatment classes are defined, as shown in Table 9. The classes have the following designations:

O - Reduction of organic matter
SO - More rigorous requirements as to reduction of organic matter and nitrification
P - Reduction of phosphorus
BOD_5 (mod.) - Modified BOD_5 analysis where nitrification is hindered

Table 9. Treatment classes for small wastewater treatment plants in Denmark. Discharge limits in mg/l. (DEPA 2000)

Treatment class	BOD_5 (mod.)	NH_3+NH_4-N	Total-P
SOP	10	5	1,5
SO	10	5	
OP	30		1,5
O	30		

Numbers and types of onsite treatment systems

In Denmark around 90% of households are connected to 1558 municipal sewage treatment plants, 86% of which provide advanced treatment (Figure 8).

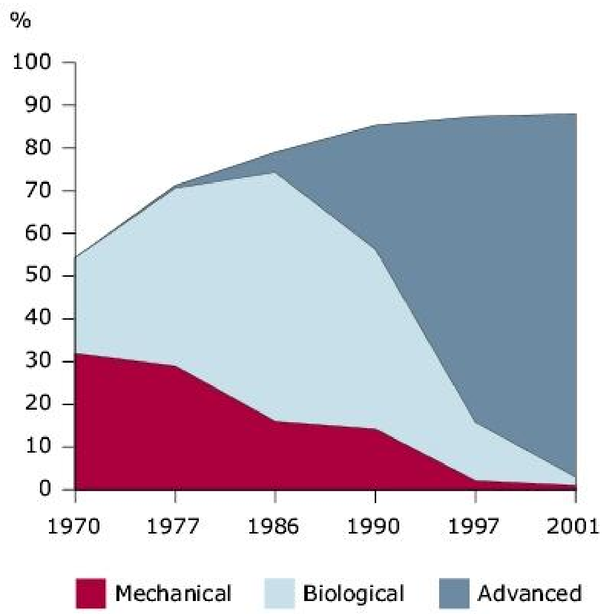

Figure 8. Share of population served with public wastewater treatment in Denmark.

Most of Danish wastewater is treated in large public wastewater treatment plants. As the requirements to the standards for wastewater treatment have increased, many smaller plants have been replaced with larger plants. Wastewater is also discharged in rural areas, from around 350 000 houses, farmhouses, holiday cottages and allotment cottages. Together these discharges account for 15% of the total sewage in Denmark. The pollution caused by the untreated discharge of this wastewater was not considered to be a problem, but as other sources of pollution (dairies, villages, manure heaps) have been disappearing it has become really visible. Approximately half of the scattered dwellings (64 000 properties) will have to change their way of sewage disposal. The effluent quality that has to be obtained depends on the sensitivity of the receiving water body and on the County's Regional Plan. Four treatment options are considered:

- Connection of these discharges to the municipal treatment plant. This is expensive for the government, but not for the house owner: the owner pays the same sewer system connection fee as all other residents in a municipality. The only part the owner needs to finance is the sewer on own ground.
- On-site treatment in a small plant.
- Infiltration into the ground, this is only possible where the soil is sufficiently sandy to let all sewage seep through. The soil should also be able to clean the sewage before it can reach the groundwater.
- Sewage disposal can continue as previously in places where it poses no threat to the surroundings.

The decision on what treatment level has to be reached lies with the municipality. Municipalities can offer to arrange the connection to the municipal treatment plant, and the owners can choose to install their own plant as long as it will provide adequate treatment.

In 2001 approximately 130 000 private residences and 13 000 summerhouses discharged directly from a settling tank into the surface water, into both fresh watercourses and the sea. The Danish government launched an action plan in 1997, with the purpose of improving the wastewater disposal situation of around 64 000 scattered settlements, including connection to public treatment plants, installing local sand infiltration plants and small wastewater treatment plants. The sand infiltration plants raise concern, as around 30 000 of these will be installed at individual houses and leaching of substances (especially household detergents) to the groundwater may happen.

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3.5 Finland

Area: 338,145 km2
Population (1,000): 5,219.7 inhabitants
Population density: 15 km^2
Capital: Helsinki
Language: Finnish, Swedish
Currency: Euro €
GDP at market prices: € 149,725.0 million
GDP per inhabitant in PPS (purchasing power standards): € 25,600
GDP growth rate: 3.6%
Inflation rate: 0.1%)
Unemployment rate: 8.8%)
Government debt/GDP: 45.1%
Public balance (government deficit or surplus/GDP): +2.1%
(Eurostat data for 2004)

Legal framework

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 phosphorus 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 p.e. in cases where nitrogen in the effluent contributes to eutrophication.

The Finnish Environment Ministry's Action Plan for the Protection of the Baltic Sea and Inland Watercourses (2005) sets a target that by 2018 all onsite wastewater systems should be equipped with best available treatment techniques. 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. The treatment of wastewater in rural areas of Finland with no centralized sewerage system will be improved greatly over the coming years, thanks to legislation in the Onsite Wastewater System Decree (542/2003), which came into force on 01-01-2004. The Decree sets minimum standards for wastewater treatment and the planning, construction, use and maintenance of treatment systems. The Decree stipulates that at least 90% of the organic material (BOD_7) should be removed from wastewater, as well as >85% of total phosphorus and >40% of total nitrogen with regard to the p.e. load defined in the Decree. Municipalities may also take local conditions into account and enforce slightly higher or lower standards in municipal environmental protection regulations where this is justifiable. The requirements in the Decree apply immediately to all new buildings, while wastewater treatment systems of buildings completed before 01-01-2004 must in most cases be upgraded to fulfill the new standards by 01-01-2004. If there is a flush toilet in a house with onsite wastewater system, the owner must prepare a description report about his wastewater system by 01-01-2006. The authorities may then consider together with residents whether the existing facilities meet the new requirements, or whether they need to be improved before 2014. If only very small amounts of wastewater are generated, "grey wastewater" from kitchens and bathrooms may be simply released into the ground untreated. This wastewater may not contain toilet waste, or represent any other type of pollution risk. Subsidies for improvements of onsite wastewater treatment systems are available from the State on social grounds. Residents can also claim tax deductions for the work done to improve wastewater systems. Some local authorities also provide support for improvements of wastewater systems in unconnected properties.

Numbers and types of onsite treatment systems in Finland

About a million people, some 20% of the population of Finland, live in houses that are not connected to centralized sewerage systems. This means that about 350,000 permanent residences and a further 450,000 holiday homes must treat their own wastewater treated on-site. The treatment systems in very many cases are obsolete or otherwise ineffective. It has been estimated that the new legislation will speed the upgrading of facilities at 200,000-250,000 properties by 2014 (Finnish Ministry of the Environment, 2006).

According to estimations of the Finnish Environmental Institute of on-site treatment of scattered living areas in municipalities of 1997 (Rautanen 2002 in Tuhkanen 2006), there were 500,000 septic tanks discharging into open ditches, 300,000 primitive soil infiltration sites, 80,000 closed containers, 60,000 soil infiltration sites, and 30,000 small packaged wastewater treatment plants, totalling about 1,000,000 sites not connected to more centralized wastewater treatment plants. It should be stressed that these figures are estimates. The Finnish Environmental Institute does not have updated information and said that it is currently trying to form a database for Finland (Santala, 2005).

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3.6 France

Area: 543,965 km^2
Population (1,000): 59,900.7 inhabitants
Population density: 110 /km^2
Capital: Paris
Language: French
Currency: Euro €
GDP at market prices: € 1,648,368.7 million
GDP per inhabitant in PPS (purchasing power standards): € 24,700
GDP growth rate: 2.3%
Inflation rate: 2.3%
Unemployment rate: 9.7%
Government debt/GDP: 65.6%
Public balance (government deficit or surplus/GDP): -3.7%
(Eurostat data for 2004)

Legal and institutional framework

The UWWTD is translated into French legislation and regulations on water by means of the Water Act 92-3 of 3 January 1992 (Articles 2, 10 and 35), Decree n° 94-469 of 3 June 1994 and the Ministerial Orders of 22 December 1994 (IFEN 2000). Following the Water Act of 1992, the municipalities have to take control of the management of individual wastewater treatment systems. On the 31st of December 2005 at the latest, a new public service should be in place. The municipalities will have to manage the realization of new installations and the quality of existing installations and verify that the owners make sure that periodic maintenance is carried out, especially the emptying of the pits (IFEN 2004).

Numbers and types of onsite treatment systems

In France the municipalities are responsible for collective wastewater treatment, and their responsibilities essentially come forth out of the Water Act (La Loi sur L'Eau) that came into force in 1992. This law introduced an integrated approach to sanitation systems and the receiving waters, and leaves the municipalities free in the way they want to use to obtain the required results. One of the obligations is to specify zones for collective wastewater treatment, individual treatment and zones that require rainwater management. In 2001 a number of 15,200 French municipalities, amounting to 42%, had specified their zones. Around 60% of the remaining municipalities have small populations of less than 400 inhabitants (IFEN 2006). The percentage of dwellings connected to the centralized wastewater treatment system is very much linked to municipality size (Figure 9).

Around 22,500 municipalities have sewers in at least part of their territory, serving 23.5 million households of a total of 29.3 million in France in 2001. This is the case of the more densely populated areas. France also has a large number of very small municipalities and a large diffuse population, which usually rely on individual treatment systems. In the majority of municipalities both systems exist, because the sewer network doesn't cover the entire territory. However, in 2001 there were 14,000 municipalities without any sewers and where individual wastewater treatment is the used system. In numbers this amounts to 5 million households or 17% of the French population. Figure 10 shows the percentage of dwellings with individual systems (IFEN 2006).

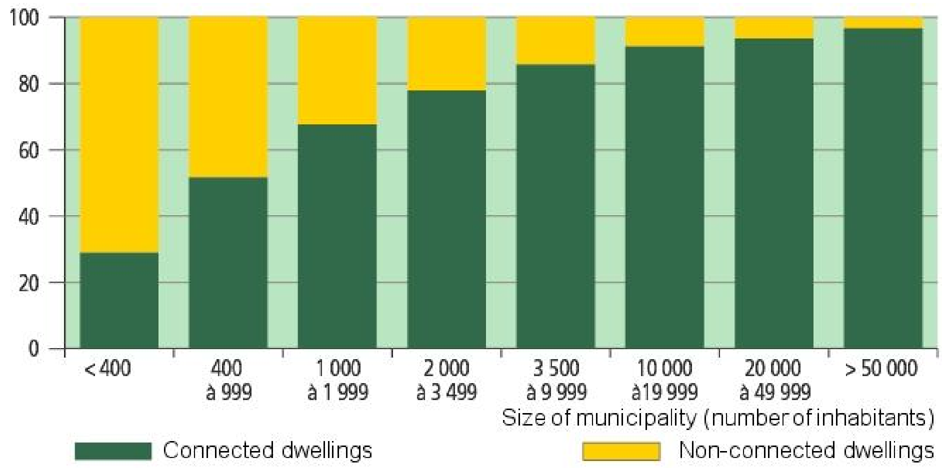

Figure 9. Percentage of dwellings connected to the French centralized wastewater treatment system related to municipality size.

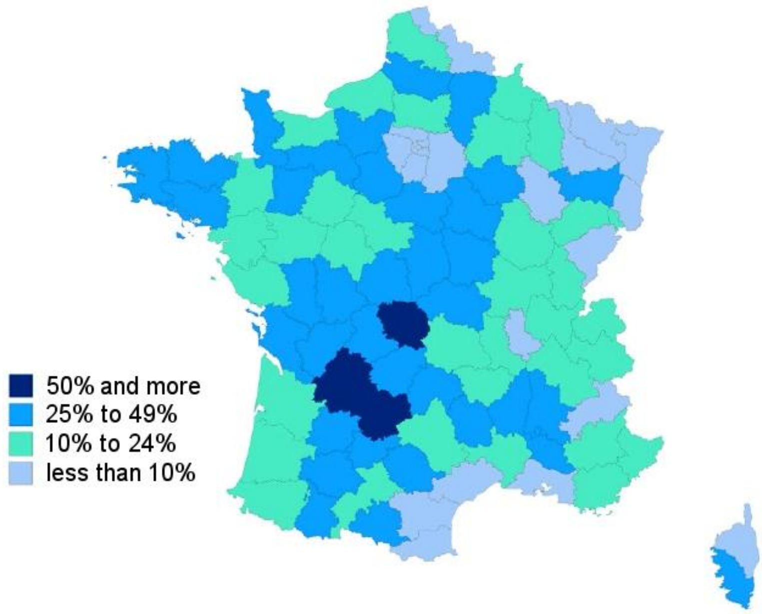

Figure 10. Percentage of dwellings with individual wastewater treatment systems (IFEN 2006)

Generally the collected wastewater is treated before discharge, either in collective or individual treatment systems. However, certain dwellings are neither connected to a sewer, nor do they have an individual system. Additionally, in 2,500 municipalities the sewers are not connected to treatment plants and are discharged without treatment outside of the inhabited areas (Figure 11). In total around 1,380,000 households discharge directly into nature: 720,000 which are not connected to sewers or to individual plants and 660,000 that discharge to sewers not connected to a treatment plant. These situations occur mostly in the departments with mountainous areas, at isolated houses in terrains that are not suitable for the traditional individual treatment techniques and where collective treatment would be too expensive.

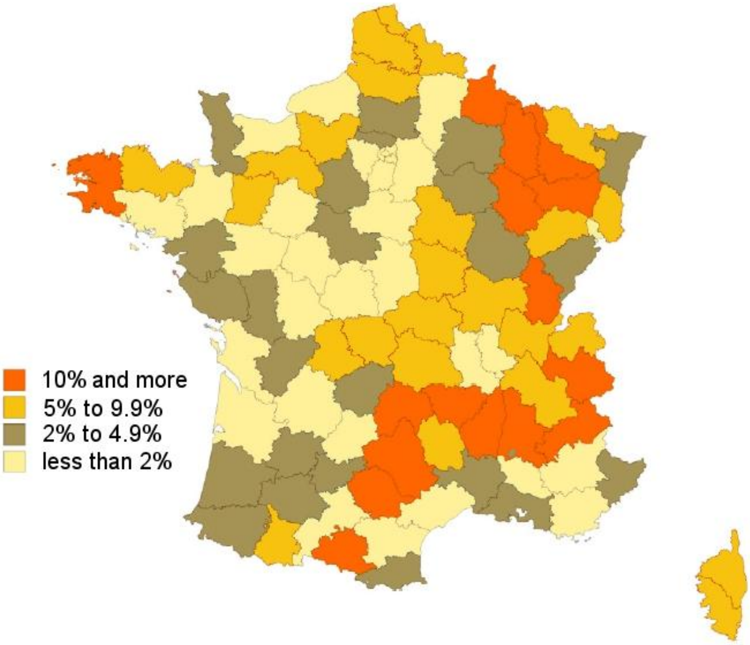

Figure 11. Percentage of dwellings discharging directly into nature (IFEN 2006).

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3.7 Germany

Area: 357,020 km^2
Population (1,000): 82,531.7 inhabitants
Population density: 231 /km^2
Capital: Berlin
Language: German
Currency: Euro €
GDP at market prices: € 2,215,650.0 million
GDP per inhabitant in PPS (purchasing power standards): € 24,400
GDP growth rate: 1.6%
Inflation rate: 1.8%
Unemployment rate: 9.5%
Government debt/GDP: 66.0%
Public balance (government deficit or surplus/GDP): -3.7%
(Eurostat data for 2004)

Legal and institutional framework

Germany has a federal structure with 16 federal states, and the governmental tasks are divided between three levels: the national, state and municipal levels. A framework of federal laws exists, and within this framework the state governments are responsible for regulation of wastewater disposal in the state's territory. Organisation and implementation of wastewater disposal is a task of the municipalities, following state laws (Rudolph and Block 2001). The federal wastewater treatment law, the Wastewater Ordinance (Abwasserverordnung), complies with European law for wastewater treatment. It specifies technical standards and requirements for the discharge of different kinds of wastewater. Regulations of the Wastewater Ordinance are further developed into state laws by the 16 federal states, taking into account the specific situation in each state. Based on the state laws, the final decisions on requirements and standards are set up by the municipalities. Where these differ from the minimum requirements specified in federal law, they can only be more demanding. In several cases local governments have voluntarily implemented extra requirements, such as further reduction of phosphorous levels or additional disinfection (Rudolph and Block 2001). According to the municipal statutes, every property owner has the obligation to connect his property to the local wastewater treatment system. Next to mandatory connection, there is also the principle of mandatory use: once connected to the local wastewater disposal system, the property owner is obliged to use it for discharge of all generated wastewater. Mandatory connection and use are part of the public health protection policy and also serve the purpose of guaranteeing a good groundwater quality. Still, the possibility of decentralized treatment exists. As the technologies for decentralized systems are more and more advanced and allow for safe operation of small plants, (semi-) decentralized concepts have gained importance (Rudolph and Block 2001).

According to the Wastewater Ordinance the effluent quality of individual treatment plants needs to comply with maximum values for COD and BOD_5 of 150 mg/l and 40 mg/l respectively. The German Institute for Construction Technology (Deutschen Instituts für Bautechnik, DIBt) has set up a division of different classes for prefabricated small wastewater treatment plants (LfW 2005):

1. Installations with carbon elimination Class C
2. Installations with additional nitrification Class N
3. Installations with additional denitrification Class D
4. Installations with additional phosphorous elimination Class C, N, D, +P
5. Installations with additional hygienisation Class C, N, D, +H

Class C meets with the minimum requirement of the Wastewater decree.

Numbers and types of onsite treatment systems

In 2001 around 95% of the overall German population were connected to sewers, and 93% were connected to a public wastewater treatment plant. There is a difference between the eastern and the western part of Germany when it comes to treatment percentages; the numbers are 76% of population and 96% respectively. Table 10 provides on overview of sewage and WWTP connection in Germany and in the different federal states. Wastewater from inhabitants that are not connected to the public systems is usually treated in individual plants, in German generally called "kleinkläranlagen". Next to individual treatment systems a "closed pit system" exists, which makes use of closed pits to collect sewage, which is then collected by truck and taken to the municipal treatment plant.

Table 10. Statistics on population and connection to sewer and WWTPs for all federal states with reference date 31-12-2001 (SBD), and the percentage of connection to WWTPs in 2003 according to the DWA (DWA 2004).

	Surface	Inhabitants		Connected to sewer, 31-12-2001				Connected
	km^2	*1000	/km^2	total	%	connected WWTP	%	WWTP %, 2003
Baden-Württemberg	35.751,64	10.717	300	10.475.562	97.7	10.458.060	97.6	99
Bayern	70.549,44	12.444	176	11.643.444	93.6	11.537.634	92.7	94
Berlin	891.82	3.388	3.799	3.337.534	98.5	3.337.534	98.5	99
Brandenburg	29.478,14	2.568	87	1.989.691	77.5	1.987.871	77.4	77
Bremen	404,23	663	1.641	656.384	99.0	656.384	99.0	100
Hessen	755,24	1.735	2.297	1.726.363	99.5	1.726.363	99.5	99
Hamburg	21.114,79	6.089	289	6.039.644	99.2	6.000.454	98.5	100
Mecklenburg-Vorpommern	23.178,53	1.720	74	1.438.615	83.6	1.434.103	83.4	82
Niedersachsen	47.619,63	8.001	168	7.421.881	92.8	7.415.961	92.7	93
Nordrhein-Westfalen	34.084,08	18.075	530	17.461.974	96.6	17.457.523	96.6	97
Rheinland-Pfalz	19.853,48	4.061	205	3.988.760	98.2	3.960.406	97.5	98
Schleswig-Holstein	2.568,69	1.056	411	1.056.837	100.1	957.115	90.6	93
Saarland	18.414,70	4.296	233	3.745.154	87.2	3.437.700	80.0	90
Sachsen	20.445,73	2.494	122	2.175.135	87.2	2.082.501	83.5	78
Sachsen-Anhalt	15.763,42	2.829	179	2.620.688	92.6	2.611.145	92.3	82
Thüringen	16.172,08	2.355	146	2.184.130	92.7	1.474.538	62.6	61
Germany	357.045,64	82.501	231	77.961.898	94.5	76.537.051	92.8	93

Figure 12 shows the total number of individual treatment systems and closed pits in Germany per federal state.

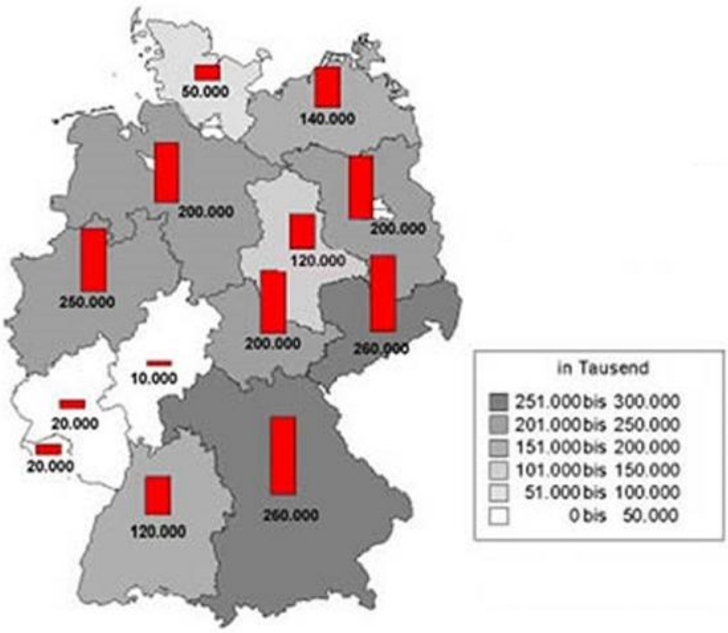

Figure 12. Number of individual treatment systems and closed pits in Germany (DWA-ST).

Situation in Baden-Württemberg

In 2001, 98.7% of the population of Baden-Württemberg was connected to a centralized wastewater treatment plant. The remaining 1.3% (amounting to around 150 000 people) is either connected to the sewer but not to a treatment plant (0.2%) or has an individual treatment plant or closed pit system (1.2%). Of the non-connected people it is foreseen that in the next 5 to 10 years around 60 000 will be hooked up to the centralized systems by means of a cost-effective pressure-sewer. On the long term around 1% of the population will be served by individual treatment plants. The types of treatment plants used in Baden-Württemberg are shown in Table 11.

Table 11. Number and types of wastewater treatment systems in Baden-Württemberg classified by size in population equivalents.

	< 500	500 - 2.000	> 2.000 - 5.000	> 5.000 - 20.000	> 20.000 - 100.000	> 100.000
Activated sludge system	12	23	32	118	139	32
Activated sludge system with sludge stabilization	61	193	143	130	14	1
Biological filters	8	11	10	5	4	2
Contact systems	25	14	1	0	0	0
Multistage systems	2	6	6	16	15	1
Wastewater ponds	33	20	5	0	0	0
Total number	141	129	197	169	172	36

Situation in Bavaria

In Bavaria the UWWTD is being implemented in the local law system since 1992, as the "Reinhalteordnung kommunales Abwasser" (ROkAbw). Bavaria is divided in four main catchment areas, namely of the rivers Main, Elbe and Donau and of the lake Bodensee. In the RokAbw areas that are identified as sensitive according to the UWWTD are specified: the catchment areas of the rivers Elbe and Main, lakes listed in the appendix of the Bavarian water law, lake Altmühlsee, lake Forggensee and the Sylvenstein reservoir and its catchment areas. In 2004 around 95.5% of the Bavarian population was connected to the sewer and practically all collected wastewater was treated in public treatment plants. In Bavaria many small municipal treatment plants with a capacity of less than 1000 i.e. are in operation, but they represent less than 2% of the total capacity. Next to these small municipal plants, around 150 000 private individual plants exist in the areas where no municipal plants are installed. On the long term it is expected that of these around 100 000 will remain. The current degree of connection for the four catchment areas is shown in Table 12, the overall connection for Bavaria in Figure 13and the spreading of small wastewater treatment plants in Figure 14.

Table 12. Connection percentages for Bavaria (LfU 2005).

Catchment area	Population	Population connected (%)	People connected	Population not connected (%)	People not connected
Main	3816250	97.9	3736109	2.1	80141
Elbe	259100	94.4	244590	5.6	14510
Donau	8273700	93.6	7744183	6.4	529517
Bodensee	92900	90.6	84167	9.4	8733

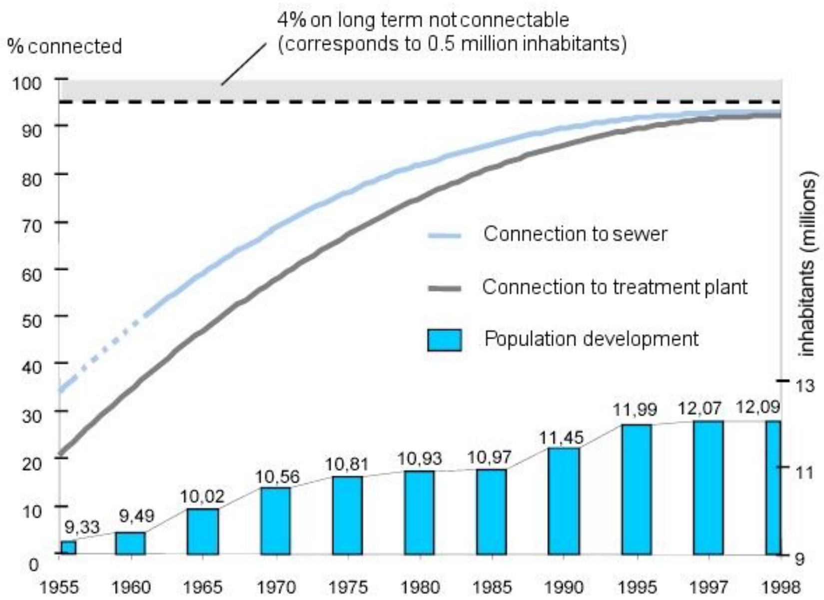

Figure 13. Connection to sewer and WWTP in Bavaria (LfW 2002).

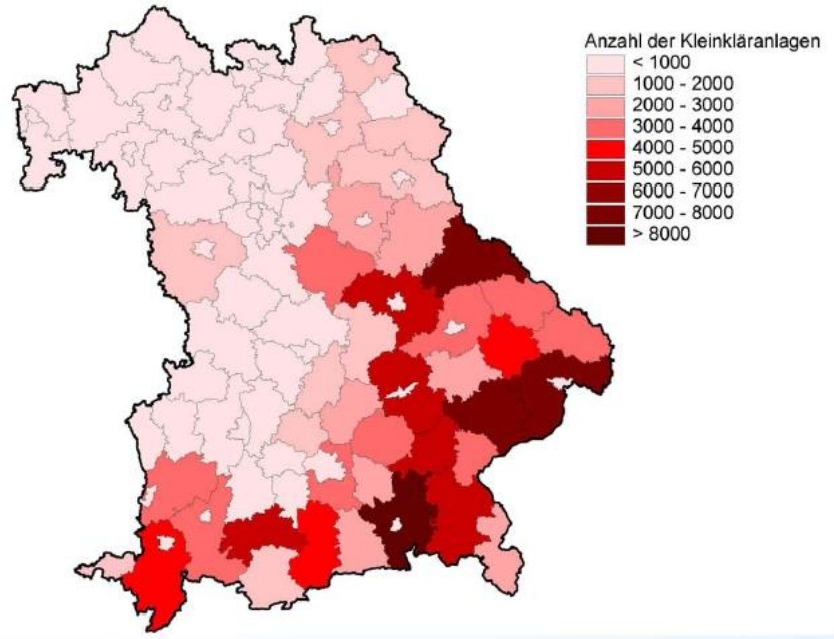

Figure 14. The spreading of small treatment plants in Bavaria (Geisenhofer 2006).

Situation in Berlin

Overall, in the year 2000 98% of the inhabitants of Berlin were connected to the sewer. In that year the amount of unconnected people was around 56 000, of which 31 000 lived in water protection areas (SfS 2001). In a press statement dated November 2004 the Berlin water companies stated that from January 1st 2006 they would become responsible for the collection pits and small treatment systems, with the objective to make sure that all wastewater generated in Berlin arrives at the sewage treatment plants. This decision would cause changes for the ca. 40 000 inhabitants that are not connected to the central sewer system and the faecal sludge transporting companies (Berliner Wasserbetriebe 2004).

Situation in Brandenburg

By the end of 2003 around 96% of household wastewater in Brandenburg was treated in public WWTPS: 80% of the population was connected to the public sewers, and the wastewater of the remaining 16% was collected in closed pits and periodically removed for treatment. Around 4% of the inhabitants treat their wastewater in individual treatment systems (Figure 15).

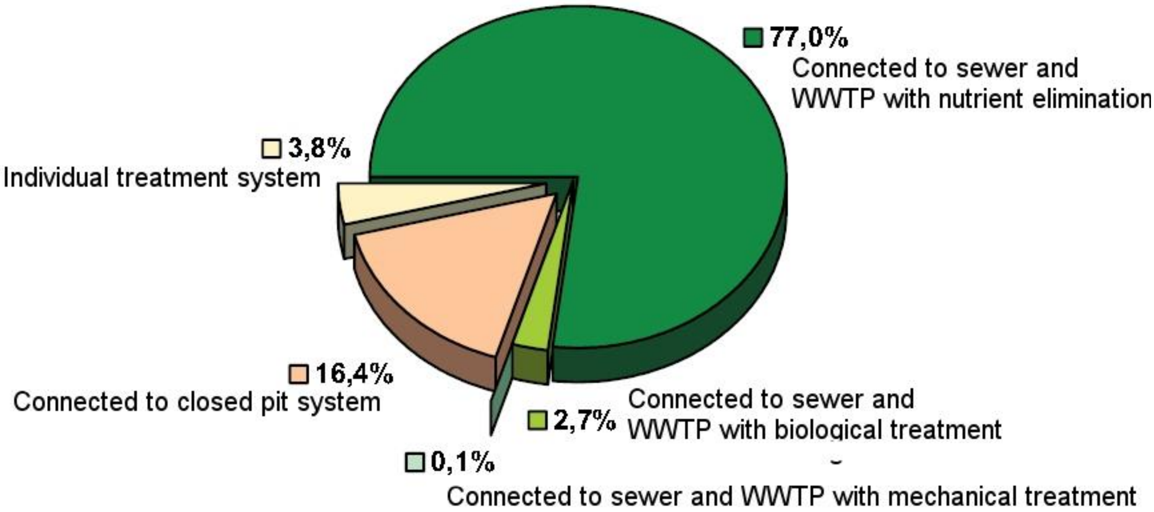

Figure 15. Wastewater treatment situtaion in Brandenburg (MLUV 2005).

Situation in Bremen

In Bremen almost a 100% of inhabitants is connected to the sewer. Wastewater of people that are not connected is mostly collected in in total 1517 closed pits. From these pits the wastewater is collected by tanker and taken to the municipal wastewater treatment plants. Additionally there are 98 individual wastewater treatment plants, serving around 320 people (Bremen 2005).

Situation in Schleswig-Holstein

On the long term it is expected that around 7% of the population in Schleswig-Holstein will remain without centralized treatment and will have to keep using an individual wastewater treatment plant. This would amount to around 200 000 people, corresponding to approximately 57 000 small plants. In total, there are around 65 180 properties treating their wastewater in individual plants, and from these 25 470 plants will need to be upgraded to comply with the generally accepted Regeln der Technik (DIN 4261, Kleinkläranlagen). Figure 16 shows the number of individual treatment plants in the rural districts and the cities for November 2002.

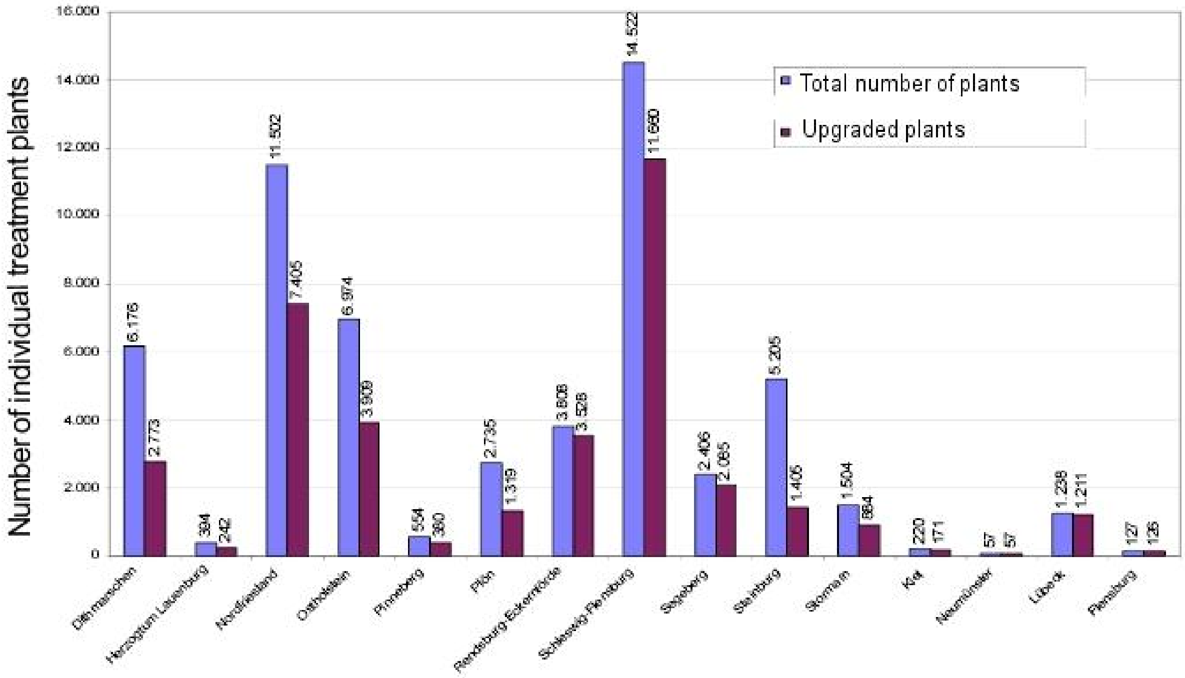

Figure 16. Total number of individual treatment plants in Schleswig-Holstein and the number of plants that has already been upgraded to latest norms. Data for November 2002 (MLUR 2005).

An inventory of the used types of biological post treatment systems shows that polishing ponds are the most used system, followed by underground seepage systems and filter trenches (Table 13).

Table 13. Different used post-treatment systems in Schleswig-Holstein (MLUR 2005).

Post-treatment system	Number of plants
Polishing ponds	14 831
Underground seepage	6 862
Filter trenches	6 599
Biological filters	2 895
Fixed bed systems	1 135
Horizontal flow wetlands	770
Vertical flow wetlands	426
SBR-systems	350
Standard activated sludge systems	257
Biological contact systems	241
Filter shafts	236
Other not technical systems	6
Other technical systems	5
Membrane systems	0
Total	34 613

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3.8 Greece

Area: 131,626 km^2
Population (1,000): 11,041.1 inhabitants
Population density: 84 /km^2
Capital: Athens
Language: Greek
Currency: Euro €
GDP at market prices: € 167,169.2 million
GDP per inhabitant in PPS (purchasing power standards): €18,300 GDP growth rate: 4.2%
Inflation rate: 3.0%
Unemployment rate: 10.5%
Government debt/GDP: 110.5%
Public balance (government deficit or surplus/GDP): -6.1%
(Eurostat data for 2004)

Sewerage and sewage treatment

From the year 1998 to the year 2000 the percentage of settlements in Greece with over 15 000 p.e. served by sewerage systems increased from 45% to 64%, and this percentage has increased more during the last years because of the construction of additional collecting systems. For settlements with over 10 000 p.e. discharging into sensitive areas the percentage of population served by WWTPs increased from 16% in 1998 to 42% in 2000. In 2000, 43% of settlements with over 15 000 p.e. discharging into normal areas was served by WWTPs. Overall, in 2001 about 60% of Greece's permanent population was served by WWTPs with at least secondary treatment, and in 2004 approximately 70% of the national population was serviced by wastewater treatment plants. It is estimated that this percentage will need to increase to 86%, as 14% of people live in villages with less than 500 p.e. and should be served by on-site treatment technologies.

In 2003 approximately 92% of the sewerage system of the Athens Basin was constructed. In the regions of Thriassio Pedio and eastern Attica sewage and storm water drainage networks did almost not exist, and most inhabitants were served by septic tanks. The Athens water supply and sewerage company EYDAP is responsible for the treatment of septic tank wastes from Attica.

The latest available data from the Greek statistics office are those obtained in the 2001 census. The results of that census as far as wastewater is concerned are shown in **Error! Reference source not found.**.

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3.9 Ireland

Area: 70,273 km^2
Population (1,000): 4,027.7 inhabitants
Population density: 57 /km^2
Capital: Dublin
Language: English, Gaelic
Currency: Euro €
GDP at market prices: € 148,557.5 million
GDP per inhabitant in PPS (purchasing power standards): € 31,400
GDP growth rate: 4.5%
Inflation rate: 2.3%)
Unemployment rate: 4.5%
Government debt/GDP: 29.9%
Public balance (government deficit or surplus/GDP): +1.3%
(Eurostat data for 2004)

Legal framework

The Local Government (Water Pollution) Act, established in 1977 and amended in 1990 and 1996, provides the primary legal framework for controlling water pollution. The Urban Waste Water Treatment (UWWT) Regulations, 2001 (S.I. 254 of 2001), which incorporate and update the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 as amended in 1999, place a responsibility on local authorities to provide treatment of urban waste water, to monitor discharges from agglomerations (communities) and to transmit the results of such monitoring to the Environmental Protection Agency (EPA, 2004). Legislation over wastewater treatment related to sensitive areas (especially for 10,000 population equivalents or more) is contained in the Urban Waste Water Treatment (UWWT) Regulations and its amendments. Discharges from agglomerations between 2,000 and 15,000 also need to have treatment facilities in place by 2005 (EPA, 2004). Legislation governing water and sewage services are mainly:

- Public Health (Ireland) Act, 1878
- Some pre - 1878 Statutes
- Local Government (Sanitary Services) Acts, 1948, 1962, 1978, 1983, 1994 and 2001
- E. U. Drinking Water Regulations, 1988 and 2000
- Arterial Drainage Acts for Land Drainage

Institutional framework

The EPA, as an agency of Ireland's national government, helps to bring all the local authorities into conformity with the same set of standards. The EPA supervises local authorities by setting national water goals. It also tests for water quality and publishes reports summarizing the state of water quality. Under the present hybrid system different groups (European Union, EPA) have different standards for water quality. Water considered polluted under EU regulations may be considered unpolluted or "satisfactory" under the EPA's classification. The EPA is required to report on a biennial basis on the quality of effluents being discharged from treatment plants, sewers or drainage pipes controlled or used by sanitary authorities. Even though the European Union does claim to exert authority over water quality, the primary responsibility for enforcing water quality regulations in Ireland lies with individual local government authorities. Each local government oversees and controls all aspects of water quality monitoring within its jurisdiction.

Sewerage and sewage treatment

In 1991, 99% of the population was connected to either public or private water supply systems (OECD, 2000). About 66% of the population in Ireland live in towns and are therefore connected to sewers. The remainder live in rural areas and are served by septic tanks. There are presently almost 500 treatment plants for towns below 2000 population equivalents and more than 50 treating sewage from towns between 2000 and 5000 population equivalents. Most of the towns which discharge to inland waters have full secondary treatment but there are about 50 towns around the coast which discharge untreated sewage to estuaries or coastal waters. Sewage discharges are a major contribution to river pollution, accounting for 48, 25, and 24% of the serious, moderate, and slight pollution, respectively, found in a number of monitoring points surveyed by the OECD (2000). However, the *total* load from sewage discharges decreased after improvements made in the sewage treatment infrastructure. The Environment action program announced by the Minister for the Environment in January 1990 provided for the elimination of untreated discharges from major coastal towns and from inland towns by the year 2000.

Onsite treatment systems in use

In Ireland, more than one third of the population (almost 1.5 million inhabitants) rely on decentralized sewage treatment systems of some kind, mostly septic tanks (EPA, 2000). Conventional systems like septic tanks followed by a percolation area, if properly installed and maintained, were found to provide good treatment where suitable subsoil conditions exist. Other systems in use are filter systems, constructed wetlands, mechanical aeration systems, and polishing filters. According to EPA (2000) there are around 350,000 decentralized systems now operating in Ireland.

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3.10 Italy

Area: 301,333 km^2
Population (1,000): 57,888.2 inhabitants
Population density: 192 km^2
Capital: Rome
Language: Italian (French and German in certain areas)
Currency: Euro €
GDP at market prices: € 1,351,327.9 million
GDP per inhabitant in PPS (purchasing power standards): € 23,500
GDP growth rate: 1.2%
Inflation rate: 2.3%
Unemployment rate: 8.0%
Government debt/GDP: 105.8%
Public balance (government deficit or surplus/GDP): -3.0%
(Eurostat data for 2004)

Legal framework

Italy is divided into 20 administrative regions, about 100 provinces and about 8000 municipalities. Management of water services are therefore very diverse and clear cut figures about sewage collection and treatment are hard to come by. For water services, it is meant here all those services linked with what Law 36 of 5 January 1994 calls “Integrated water service” i.e. supplying - fetching, transporting and distributing - water for domestic use, as well as collection and treatment of wastewater. At present these services are still very fragmented, from the point of view of both territory and management. This fact may explain why the statistical knowledge of this field is still so poor, as shown by the fact that the latest complete overview dates back to 1996.

The first Italian regulations on water destined for recreational use date as far back as 1896. Those particular regulations forbade swimming within 200 metres from any sewage outlet. The most recent legislative act on water pollution control and water quality improvement has been the Legislative Decree 152/1999 (modified by Legislative Decree 258/2000). It has been conceived in order to adopt into Italian legislation the European Directives 91/271 on urban wastewater treatment and 91/676 on protection of water from agricultural pollution. It also rearranged all previous Italian legislative framework on pollution control, replacing the fundamental Law 319/1986 (Merli Act). In fact, the Decree 152/1999 has introduced the objectives of a minimum standards of water quality and of a specific level connected to each particular use (production of drinking water, bathing, etc.), by modifying the previous discipline of the standards on wastewater effluents. In particular, it has fixed different requirements for different zones distinguishing the vulnerable zones (subject to nitrates and phytosanitary products pollution) and the areas sensible to eutrophication process. However, as recently as December 2001, the European Commission has taken Italy to the Court of Justice due to its lack of sufficient treatment for wastewater from the city of Milan, now the largest European urban area that still lacks basic water treatment.

Institutional framework

At national level, the Prime Minister is responsible for defining guidelines on water resources, methodologies for water planning, as well as for defining the criteria for water transfer, among other tasks (Decree 4/3/96). At river basin level, the river basin authority is in charge of evaluating and updating the water balance, of indicating measures for water economy planning and of managing public financial investments for hydraulic infrastructures. At regional level, each region cooperates with interregional river basin authorities, establishes the regional river basin authorities, determines the organization of the relationships among local authorities, adopts water saving programs, and establishes criteria for personnel transfer to water firms, among other tasks (Decree 152/1999). At local level, the OTU (Optimal Territorial Units) authorities are responsible for planning, control and vigilance on water services provision through regulation tools like a) The "OTU Plan" which defines the investments and the related financial sources; b) The agreement between authorities and firms who would manage the water services, including the objectives to be attained and the penalties in case the services would not work well; c) The competition for acquiring the water service through a competitive tendering; d) The tariff, established according to the methodology defined by the Committee for Water Resources Use, with reference to firm's proposal and taking into account social sustainability; and e) The service chart, stating customer rights and firms' obligations (according to Prime Minister Decrees 4/3/96 and 29/4/99).

Sewerage and sewage treatment

Only 73% of the population is currently connected to a sewerage network and 28% of this network requires renewal or upgrading. Sewerage is mostly combined (rainwater and sewage conveyed together), which poses problems with fluctuating flows arriving at wastewater treatment plants. In term of municipal wastewater treatments about half of the country's sewage effluent are discharged into receiving waters, one quarter undergoes primary treatment only, and one quarter receives secondary treatment or higher. Only about half of the municipalities, comprising just over 60% of the total population are connected to treatment plants. There are several small plants providing only primary treatment although 97% of the purification capacity is offered by plants carrying out secondary treatment and tertiary treatment is still very scarce. As far as sludge treatment and disposal are concerned 80% is dumped in landfills. Sewerage and wastewater treatment systems show a great variability among regions. However, there is a residual demand of several millions population equivalents if the requirements of EC directive 91/271 are to be met. This directive requires the progressive installation by the year 2005 of secondary treatment capacity for all settlement with an IE-number greater than 10000. The sums allocated for this purpose are quite insufficient to cover the investments needed. The local water utilities will be expected to meet the balance through the use of their new powers of charging the full capital and operating costs of providing water services.

Onsite treatment systems in use in Italy

It was estimated that there are still millions of septic tanks still in use in cities all over Italy in spite of the fact that its use has been explicitly forbidden by law in 1977 (Masotti and Verlichi, 2005). Italian laws are more favorable to the use of Imhoff tanks than they are for septic tanks and some guidelines for dimensioning and design principles were suggested for different population sizes. It is unclear how many Imhoff tanks are now in operation. Italian law (Decree 152/99) is also in favor of the use of so-called “natural systems” like wetlands, ponds, reed beds or small trickling filters for settlements between 50 to 2000 population equivalents. The estimated amount of constructed wetlands under operation in Italy is shown in Figure 17 (Pucci, 2000). The use of other systems, or combinations between systems like septic and Imhoff tanks with rotating biological contactors (biorotors), sequential batch reactors, sedimentation tanks, membranes, and so on, is also under study but the actual number of plants in operation is not well documented.

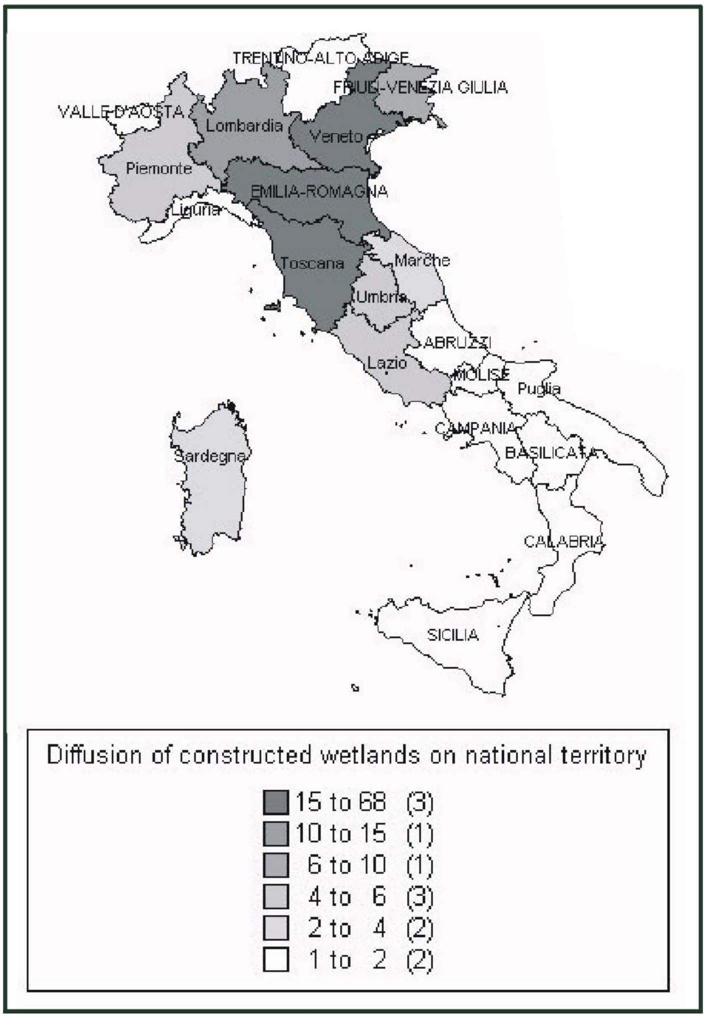

Figure 17. Use of constructed wetlands in Italy.

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3.11 Luxemburg

Area: 2,586 km2
Population (1,000): 451.6 inhabitants
Population density: 175 /km^2
Capital: Luxembourg
Language: Luxembourgish, German, French
Currency: Euro
GDP at market prices: € 25,663.5 million
GDP per inhabitant in PPS (purchasing power standards): € 49,700
GDP growth rate: 4.5%
Inflation rate: 3.2%
Unemployment rate: 4.8%
Government debt/GDP: 7.5%
Public balance (government deficit or surplus/GDP): -1.1%
(Eurostat data for 2004)

Numbers and types of onsite treatment systems

Since 1970 in Luxemburg the total amount of treated wastewater grew from 202 to 807 p.e. During the same period the percentage that was treated biologically (secondary and tertiary treatment) rose from 30% to close to 95%. By the end of the year 2002 the part of the population that was not connected to treatment plants amounted to around 25 000 inhabitants. In the majority of those cases the wastewater is pre-treated in private septic tanks and then discharged into the public sewer or into the natural environment. (Ministère de l'Environnement 2003). A specific number is given for the situation in 2003: 23 397 inhabitants were not connected to public sewage treatment works (La Direction de la Gestion de l'Eau 2003).

Table 14. Wastewater treatment plants in Luxemburg in 2004 (statec).

Capacity (p.e.)	Total	³ 20 < 500	500 < 2000	2000 < 10000	10000 < 500000
Mechanical plants	177	169	7	1	-
Biological plants	107	37	31	28	11
Biological plants - secondary treatment	102	37	31	27	7
Biological plants - tertiary treatment	5	-	-	1	4
Activated sludge	65	10	20	25	10
Bacterial filters	6	4	2	-	-
Bacterial disks	5	1	1	3	-
Naturally aerated lagoons	15	14	1	-	-
Artificially aerated lagoons	5	3	1	-	1
Artificially aerated lagoons with bacterial disks	6	-	6	-	-
Macrophyte fields	5	5	-	-	-

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3.12 The Netherlands

Area: 33,882 km^2
Population (1,000): 16,258.0 inhabitants)
Population density: 480 /km^2
Capital: Amsterdam
Language: Dutch (Frisian in some areas)
Currency: Euro €
GDP at market prices: € 488,642.0 million
GDP per inhabitant in PPS (purchasing power standards): € 27,900
GDP growth rate: 1.7%
Inflation rate: 1.4%
Unemployment rate: 4.6%
Government debt/GDP: 55.7%
Public balance (government deficit or surplus/GDP): -2.5%
(Eurostat data for 2004)

Legal and institutional framework

In The Netherlands, so-called Waterschappen (Water Boards) are responsible for water quantity and water quality management, and all Dutch homes and other buildings belong to the working area of one of the water boards. In this way there is a good administrative coverage of all sewer connections. In the field of sewerage many actors have to work together, in The Netherlands they are organised in RIONED Foundation. RIONED is the interest group for urban drainage concerns in the Netherlands, it is the umbrella organization in which public bodies, industry and the educational sector cooperate. Around 98% of the Dutch population receives wastewater treatment. Figure 18 shows the development of wastewater treatment in the last decades (EEA 2005).

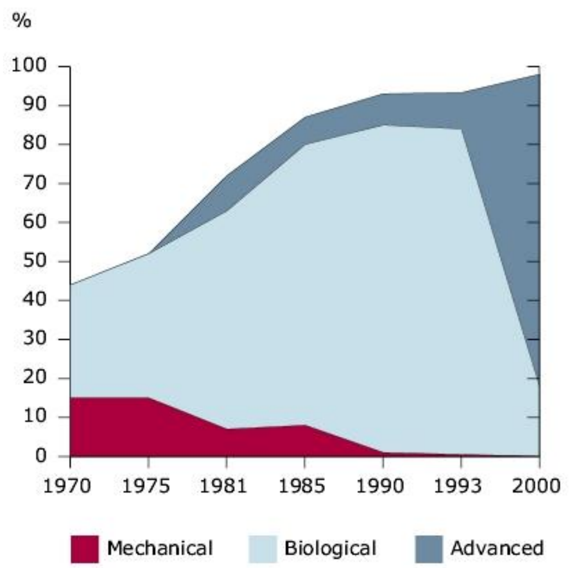

Figure 18. Share of population served with public wastewater treatment in the Netherlands.

The percentage of connection to a sewer is high in The Netherlands, which is the logical result of having a large population density. Table 15 shows the percentage of people connected to the sewer.

Table 15. Percentage of people in The Netherlands connected to a sewer system (2005).

Type of connection	Number of inhabitants	Portion (%)
Combined sewer system	11,900,000	73
Separated sewer system	2,690,000	17
Improved separated sewer system	1,010,000	6,2
Pressure sewer system	460,000	2,8
Not connected (discharge to surface water and ground)	230,000	1,4
Total number of inhabitants	16,255,000	100

Numbers and types of onsite treatment systems

As of the year 2005, the discharge of non-treated wastewater into the soil or the surface water in The Netherlands is forbidden by law. All households and farmers in the rural areas who are not connected to the sewer or have inadequate systems are facing changes. Before 2005 everyone should have started using an adequate system for individual wastewater treatment, in Dutch called IBA-systeem (*systeem voor Individuele Behandeling van Afvalwater*). This goal has not been met, but implementation of IBA's is well underway. For the four different IBA types emission criteria have been set for a number of water quality parameters, as shown in Table 16.

Table 16. Emission criteria for different types of IBAs.

	IBA class 1		IBA class 2		IBA class 3a		IBA class 3b	
	sample [a]	24h [b]	sample [a]	24h [c]	Sample [a]	24h [c]	sample [a]	24h [c]
BOD_5	< 250	> 30	< 60	< 30	< 40	< 20	< 40	< 20
COD	< 750	> 30	< 300	< 150	< 200	< 100	< 200	< 100
Suspended solids	< 70	> 75	< 60	< 30	< 60	< 30	< 60	< 30
N-total	-	-	-	-	< 60	< 30	< 60	< 30
Ammonium	-	-	-	-	< 4	< 2	< 4	< 2
P-total	-	-	-	-	-	-	< 6	< 3

[a] in any given sample mg/L, [b] percentage removal, [c] 24 h volume proportional sample mg/L

In 2002 a total of 147,674 plots were not connected, this number is expected to decrease to a number of 52,947 unconnected plots after finishing the program for complete sanitation which is now in progress. Of these plots around 20,000 will be served by a non-IBA system such as a septic tank, 20,000 by an IBA 1, 7000 by IBA 2 and 6000 by an IBA 3 system.

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3.13 Portugal

Area: 91,906 km2
Population (1,000): 10,474.7 inhabitants
Population density: 114 /km^2
Capital: Lisbon
Language: Portuguese
Currency: Euro
GDP at market prices: € 142,433.0 million
GDP per inhabitant in PPS (purchasing power standards): € 17,100
GDP growth rate: 1.0%
Inflation rate: 2.5%
Unemployment rate: 6.7%
Government debt/GDP: 61.9%
Public balance (government deficit or surplus/GDP): -2.9%
(Eurostat data for 2004)

According to the Portuguese State of the Environment 2003 report (REA 2003), in 2002 close to 73% percent of the population in Portugal was connected to the sewer system, with percentages above average in the regions of Lisbon and Vale do Tejo, Alentejo and the Algarve, and percentages below the national average in the regions of the North, Centre, Madeira and the Azores. The unconnected population amounts to around 2.9 million people. With respect to wastewater treatment, in 2002 the percentage of population connected to WWTPs reaches just 57%. In the Azores, Madeira and the North region the treatment percentage is lowest. Of the amount of collected wastewater 73% receives treatment, as shown in Figure 19, Figure 20, and Table 17.

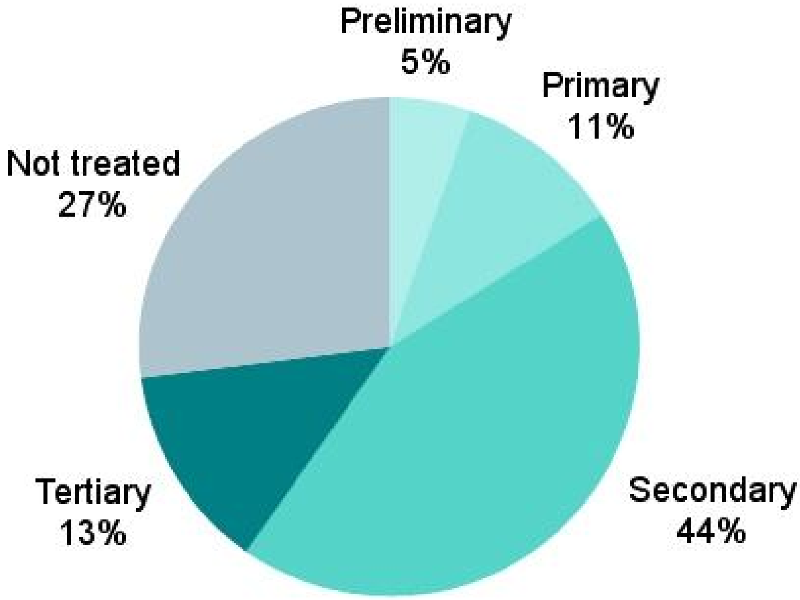

Figure 19. Treatment type for collected wastewater in Portugal in 2002.

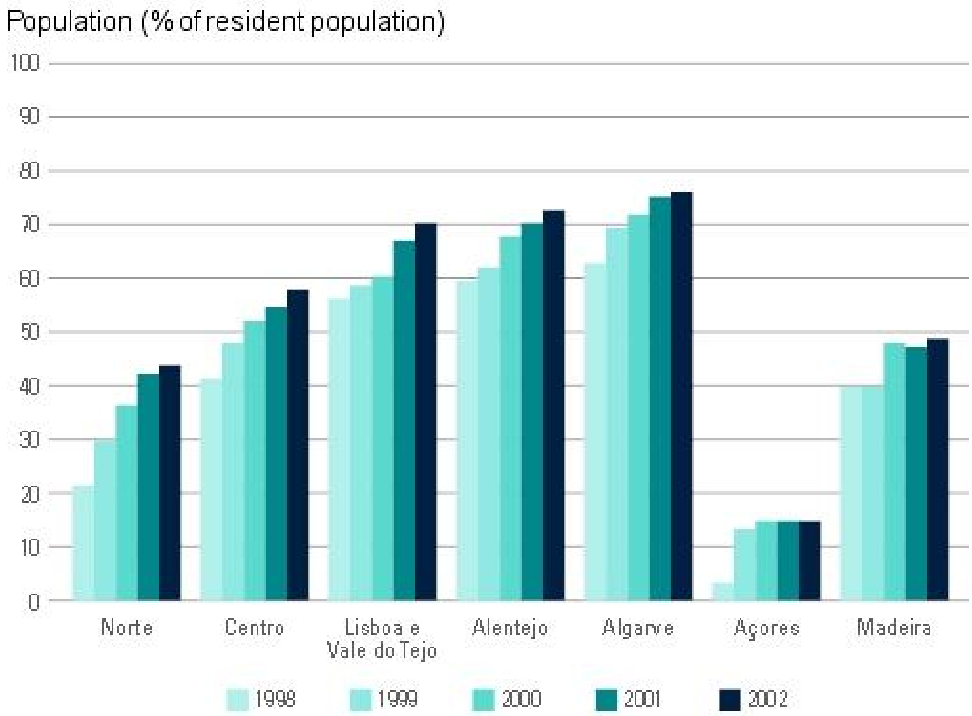

Figure 20. Percentage of resident population connected to wastewater treatment systems.

Table 17. Connection to sewer system and to wastewater treatment plants in Portugal in 2003. Treatment plants include municipal septic tanks.

Area	Sewers				Treatment	
	Produced effluent volumes (1000 m^3)			Population served with sewers (%)	Treated volume (1000 m^3)	Population served with WWTPs (%)
	Total	Residential and services	Industrial			
Portugal	526 138	428 331	97 807	73.5	433 038	60.4
Continent	504 133	410 730	93 403	74.9	415 704	61.7
-Norte	132 398	104 264	28 134	59.6	107 052	49.3
-Centro	95 781	79 787	15 994	70.3	84 681	59.8
-Lisboa	196 514	159 312	37 202	96.5	153 579	76.1
-Alentejo	36 816	32 316	4 500	83.0	30 429	68.3
-Algarve	42 624	35 051	7 573	82.5	39 963	77.0
R. A. Açores	6 727	5 417	1 310	36.3	2 146	19.6
R. A. Madeira	15 278	12 184	3 094	54.8	15 188	50.0

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INSAAR Inventário Nacional de Sistemas de Abastecimento de Água e de Águas Residuais, http://insaar.inag.pt/

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3.14 Spain

Area: 505,790 km^2
Population (1,000): 42,345.3 inhabitants
Population density: 84 /km^2
Capital: Madrid
Language: Spanish, Catalan, Galician, Basque, Valencian
Currency: Euro
GDP at market prices: € 837,557.0 million
GDP per inhabitant in PPS (purchasing power standards): € 22,000
GDP growth rate: 3.1%
Inflation rate: 3.1%
Unemployment rate: 11.0%
Government debt/GDP: 48.9%
Public balance (government deficit or surplus/GDP): -0.3%
(Eurostat data for 2004)

Framework

Responsibility for water management in Spain is shared between different levels of government, including 14 River Basin Authorities (RBAs). Autonomous regions (which are responsible for irrigation and coastal water quality) have passed their own legislation. Municipalities regulate industrial discharges to sewerage systems. Water services are a municipal responsibility but actual delivery depends on a number of different management structures. Water supply and and wastewater treatment is carried by a local authority (19%), public companies (45%) or by the private sector (36%).

Numbers and types of onsite treatment systems

According to a report by the OECD, in Spain close to 80% of the overall population is connected to sewers, and for the big cities this number reaches 93% (Table 18). Around 16% is not connected to sewers; this amounts to some six million people. The importance of tourism in Spain shows also in wastewater production: the amount of wastewater collected in sewers is the equivalent of almost 70 million p.e., of which 34 million p.e. come from the permanent population, and 10 million p.e. from tourists. The remaining fraction is produced by industry and agriculture. In the year 2000, around 66% of the collected wastewater was served by the public wastewater treatment network, the estimation is that this corresponds to 55% of the Spanish population (Table 19, Figure 21). With respect to complying with the UWWTD, Spain has still to make a big effort. The deadline of the year 2000 for adequate treatment of all cities with discharges over 15,000 p.e. was not met, and in that year only Navarra and Madrid were expected to comply with the next deadline; adequate treatment over communities over 2000 p.e. by 2005. In 2001 only 171of the then installed 1326 WWTPs were equipped with tertiary treatment (OECD 2004). The Spanish environmental ministry states that in 2002 around 81% of wastewater was treated, based on population equivalents (see Figure 22).

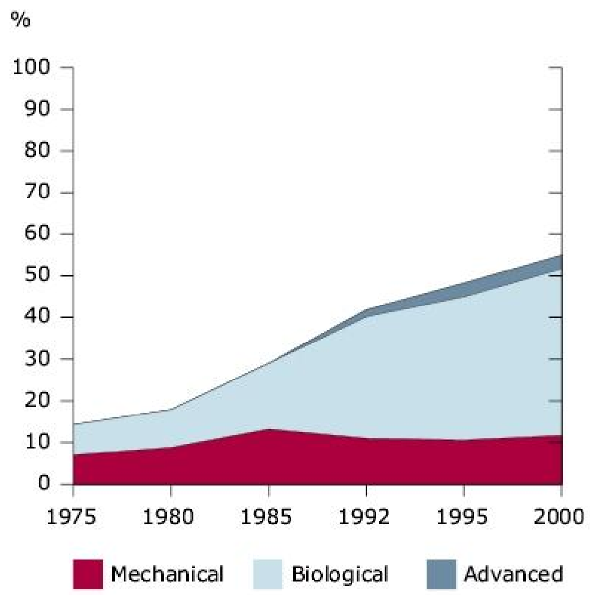

Figure 21. Share of population served with public wastewater treatment in Spain.

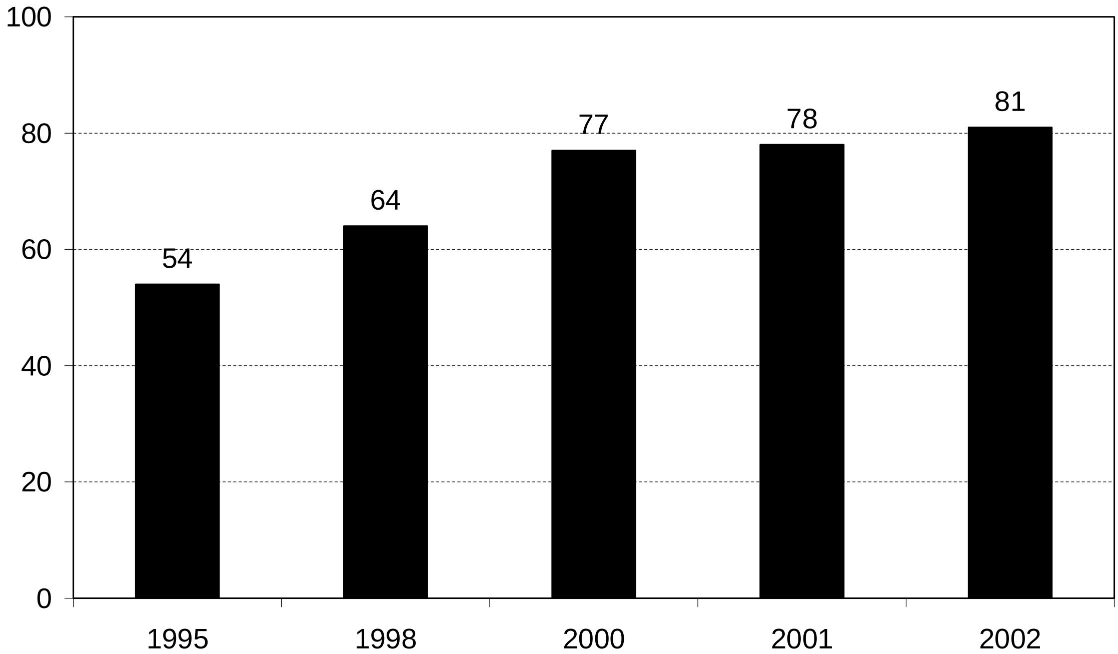

Figure 22. Percentage of population equivalents treated in the last decade.

Table 18. Statistical information on connection to sewer system for municipalities with less than 50,000 inhabitants. Information on the País Vasco, Navarra and Cataluña is missing.

Autonomous Communities	Dwellings					Inhabitants				
	Total	With service		without service		Total	With service		without service	
	number	number	%	number	%	number	number	%	Number	%
Andalucía	1872789	1837976	98.14	34813	1.86	3794999	3753382	98.9	41617	1.1
Aragón	349872	347455	99.31	2417	0.69	590023	588206	99.69	1817	0.31
Asturias	244491	192788	78.85	51703	21.15	519961	413543	79.53	106418	20.47
Illes balears	285216	261043	91.52	24173	8.48	466664	448727	96.16	17937	3.84
Canarias	365016	225640	61.82	139376	38.18	867276	576044	66.42	291232	33.58
Cantabria	127219	105798	83.16	21421	16.84	275758	221919	80.48	53839	19.52
Castilla- León	898230	888965	98.97	9265	1.03	1389870	1383771	99.56	6099	0.44
Castilla-Mancha	690537	686718	99.45	3819	0.55	1269699	1266418	99.74	3281	0.26
Extremadura	393699	392125	99.6	1574	0.4	801024	798160	99.64	2864	0.36
Galicia	738035	471920	63.94	266115	36.06	1574273	1006927	63.96	567346	36.04
Madrid	445665	437966	98.27	7699	1.73	814123	809779	99.47	4344	0.53
Murcia	235293	232202	98.69	3091	1.31	534534	531481	99.43	3053	0.57
La Rioja	85162	84892	99.68	270	0.32	149770	149595	99.88	175	0.12
C. Valenciana	1258420	1190150	94.57	68270	5.43	2207005	2167540	98.21	39465	1.79
Total Spain	7989644	7355638	92.06	634006	7.94	15254979	14115492	92.53	1139487	7.47

Table 19. Statistical information on connection to wastewater treatment for municipalities with less than 50 000 inhabitants. Information on the País Vasco, Navarra and Cataluña is missing.

Autonomous Communities	Dwellings					Inhabitants				
	Total	With service		Without service		Total	With service		Without service	
	number	number	%	number	%	number	number	%	number	%
Andalucía	1872789	852080	45.5	1020709	54.5	3794999	1560495	41.12	2234504	58.88
Aragón	349872	162135	46.34	187737	53.66	590023	295452	50.07	294571	49.93
Asturias	244491	107724	44.06	136767	55.94	519961	231956	44.61	288005	55.39
Illes balears	285216	255364	89.53	29852	10.47	466664	428151	91.75	38513	8.25
Canarias	365016	191484	52.46	173532	47.54	867276	456979	52.69	410297	47.31
Cantabria	127219	46513	36.56	80706	63.44	275758	106868	38.75	168890	61.25
Castilla y León	898230	518520	57.73	379710	42.27	1389870	829969	59.72	559901	40.28
Castilla-Mancha	690537	371266	53.76	319271	46.24	1269699	756179	59.56	513520	40.44
Extremadura	393699	139506	35.43	254193	64.57	801024	324418	40.5	476606	59.5
Galicia	738035	383579	51.97	354456	48.03	1574273	768235	48.8	806038	51.2
Madrid	445665	340075	76.31	105590	23.69	814123	638178	78.39	175945	21.61
Murcia	235293	204872	87.07	30421	12.93	534534	487351	91.17	47183	8.83
La Rioja	85162	70858	83.2	14304	16.8	149770	124452	83.1	25318	16.9
C. Valenciana	1258420	854540	67.91	403880	32.09	2207005	1447022	65.56	759983	34.44
Total Spain	7989644	4498516	56.3	3491128	43.7	15254979	8455705	55.43	6799274	44.57

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3.15 Sweden

Area: 449,964 km2
Population (1,000): 8,975.7 inhabitants
Population density: 20 /km^2
Capital: Stockholm
Language: Swedish
Currency: Swedish crown
GDP at market prices: € 279,007.7 million
GDP per inhabitant in PPS (purchasing power standards): € 25,900
GDP growth rate: 3.6%
Inflation rate: 1.0%
Unemployment rate: 6.3%
Government debt/GDP: 51.2%
Public balance (government deficit or surplus/GDP): +1.4%
(Eurostat data for 2004)

Legal framework

The Swedish Environmental Protection Agency is the central environmental authority under the Swedish Government in charge of the co-ordination and promotion of environmental work on both a national and international level (Swedish EPA, 2006). In Sweden, water supply and sewage disposal are by law a municipal responsibility.

The Swedish Parliament has established 16 environmental quality objectives in the so-called Environmental Code, such as "Clean Air" and "Good-Quality Groundwater", to guide Sweden towards a sustainable society. The 16 environmental objectives will function as benchmarks for all environment-related development in Sweden, regardless of where it is implemented and by whom. The overriding aim is to solve all the major environmental problems within one generation.

In 1994, Sweden identified all of its waters as a sensitive area. In Sweden the Environmental Act regulates the discharge of the wastewater effluent. It contains no effluent demands for BOD, P, and SS. The effluent of wastewater treatment plants at the sea is defined by EU legislation and considers for N-total the threshold value of 10, and 15 mg/L for respectively plants of <100,000 p.e. and >100,000 p.e. These values do not count for treatment plants north of Norrtälje. Above this city the temperature is in general so low that the biological nitrogen removal is reduced. Eutrophication in the seawater off Central and Southern Sweden have prompted stricter stipulations concerning nitrogen removal at major treatment plants on the coast although nearly three fourths of municipal wastewater discharged from the coasts of Sweden in 2000 underwent special nitrogen removal.

There are no specific regulations with respect to small wastewater treatment plants, except for the legal requirement that on-site systems should be 'more effective than sludge removal alone'. Further requirements are formulated an the municipal level based on the 16 environmental quality objectives. Guidelines about small domestic wastewater treatment plants state the performance and/or function requirements, life expectancy, ease of use and maintenance for waste water treatment plants.

Numbers and types of onsite treatment systems

Municipal wastewater in Sweden today is far more comprehensively treated than it used to be a few decades ago. Today all urban households without exception are connected to sewage treatment plants and around 95 per cent of urban wastewater undergoes both chemical and biological treatment and as much as 54% also go through special nitrogen removal (Figure 23). Under municipal control and with financial support from the state, intensive construction of treatment plants was carried out during the 1960s and 1970s. Sewage disposal infrastructure for municipal use encompasses around 2000 sewage treatment plants and 92,000 km of sewers.

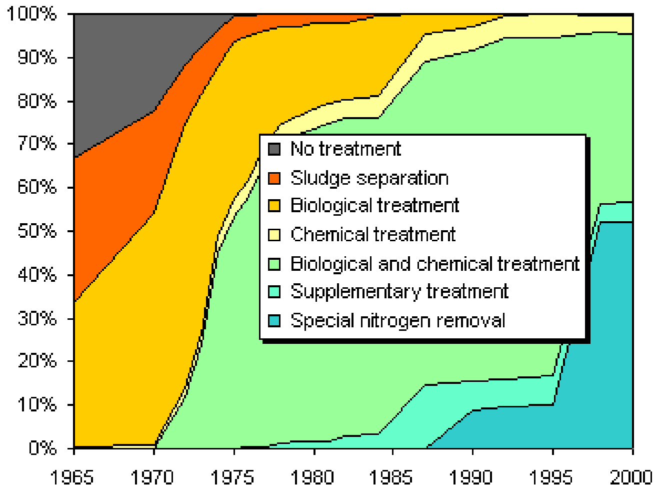

Figure 23. Urban households connected to sewage treatment in Sweden. Numbers refer to the almost 500 treatment plants designed to deal with wastewater from at least 2,000 p.e..

Sweden has 134 agglomerations with a population equivalent of more than 10,000, that is 7,672,670 people. All these agglomerations are connected to an urban sewer system. This means that 15% of the Swedes, equalling 1.3 million people are living in rural areas. It is estimated that about 500,000 permanent dwellings in Sweden are not connected to the municipal sewage system (and about as many holiday homes). Of these households, around half have no more advanced treatment than sludge separation, and 50-60% are judged not to adhere to the Environmental Code's requirements for wastewater purification.

The 2005 European Environment State and Outlook reports that for the year 2000 the following assumptions have been made: all people living in urban areas are connected to MWWTPs, of the people not living in urban areas 192 000 persons are connected to a MWWTP, 70 000 have no treatment at all, the remaining 1 163 000 have septic tanks of which 60 % have at least secondary treatment.

The most common systems, other than sludge separation (e.g. three compartment septic tanks), are infiltration systems, sub-soil filters and micro-treatment plants. Sand filter trenches, soak away fields, re-sorption plants are also commonplace but cannot be considered to fulfil requirements for acceptable wastewater treatment. Different source separation systems are becoming increasingly common, and can be separated into water flushing and dry systems.

The Stockholm water company carried out an evaluation of small wastewater treatment systems in 2000-2002. After a technology competition in 1998/99 15 small wastewater plants were chosen from 8 suppliers. The plants were installed and their function and result was analyzed over a three year period. Each of the plants reached, or demonstrated that it was possible to reach, the target of at least 90% BOD and phosphorus reduction and 50% nitrogen reduction. The 15 plants were of three different kinds – source separating systems, small wastewater treatment plants and chemical precipitation with sub-soil filter. The evaluated small wastewater treatment plants included sequenced batch reactors, biofilm reactors and activated sludge systems.

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3.16 United Kingdom

Area: 243,820 km^2
Population (1,000): 59,673.1 inhabitants
Population density: 245 $/km^2$
Capital: London
Language: English (Welsh and Gaelic in some areas)
Currency: British pound
GDP at market prices: € 1,715,059.1 million
GDP per inhabitant in PPS (purchasing power standards): € 26,500
GDP growth rate: 3.2%
Inflation rate: 1.3%
Unemployment rate: 4.7%
Government debt/GDP: 41.6%
Public balance (government deficit or surplus/GDP): -3.2%
(Eurostat data for 2004)

Legal framework

The UK is taking measures to comply with the Urban Waste Water Treatment Directive passed in 1991 (91/271/EEC). This Directive concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. The Directive has requirements for sewerage to be established and sets standards for sewage treatment. The general principle of the Directive is to provide treatment of sewage from the largest discharges first, and to protect sensitive waters. In England and Wales the Urban Waste Water Treatment Regulations are in place since 1994.

Institutional framework

The enforcement of legislation on water and wastewater is carried out by several institutions and organizations within the UK. Among them, the Environment Agency, the Scottish Environment Protection Agency (SEPA), Northern Ireland DoE, the Environment Protection Agency of Ireland, and the Department for Environment, Food and Rural Affairs (DEFRA). Sewage collection and treatment is done mostly by private companies operating on different ownership modes.

Sewerage and sewage treatment

About 96% of the UK population is connected to sewers leading to sewage treatment works. Most of the remainder are served by small private treatment works, cesspits or septic tanks (DEFRA, 2006). Sewage collected is treated at about 9000 sewage treatment works around the country. The UK was 90% compliant in 2000 with the requirement of the Directive to provide secondary treatment for discharges from agglomerations of more than 15000 population equivalents (projections were 98% compliance by 2002). According to the OECD Environment Program, eight cities of more than 150000 people still lack treatment plants in the UK. Most of the areas originally identified as less sensitive were later redefined as sensitive areas and secondary treatment was provided to discharges in these areas as well. The presence of overflows outlets needed to deal with excess water during some rainstorms has created some problems and specific measures are being taken to prevent pollution from these sources. According to DEFRA (2006) the number of agglomerations from 2000 to 10000 population equivalents in the UK is currently 1078, from which 51 discharge into freshwater and estuaries identified as sensitive areas and only 2 to less sensitive areas. However, according to a report of the European Commission the UK has no ”less sensitive areas” since July 2002 (EC, 2004). The remaining sites discharge on normal areas. Secondary treatment will be applied to coastal discharges down to 2000 population equivalents in England and Wales (rather than the 10000 population equivalents specified in the Directive). Higher levels of treatment than those specified under the Directive may be required to meet other Community Directives such as the Bathing Water Directive or Shellfish Waters Directive.

Onsite treatment systems in use

According to the Environment Agency for England and Wales (2004) the preferred disposal option for sewage is always connection to the public sewerage. Only when this option is not available, then the following options should be considered: septic tank, package treatment plant, reed bed system, waterless toilet, cesspool, or a combination of these.

Constructed wetlands are one of the systems increasingly being utilized for sewage treatment and urban surface runoff in the UK. The introduction of constructed wetlands to treat surface runoff followed an official report in 1997 advocating the use of “soft engineered” facilities to contribute to sustainable development in this sector. Shutes *et al.* (2005) presented data on 103 systems treating runoff water coming from different areas. The use of Reed Bed Treatment Systems for sewage is generally accepted by the water industry as an appropriate treatment for small villages. There are now between 200 and 300 systems in operation since the early experiences in 1985 (Cooper and Green, 1995). Other systems like Rotating Biological Contactors (RBC) are used to provide secondary treatment for populations between 50 and 2000 population equivalents. More than three hundred systems were reported by Griffin and Findlay (2005).

Actual figures about the numbers of systems in place are hard to come by. Assuming that about 98% of the 60 million inhabitants of the UK are connected to the sewerage and based on 4-person households we can calculate that there could be as much as 300 000 individual systems still in place. In fact, there are still about 100 000 discharges from smaller sewage or trade discharges (less than 5m^3/day) and other discharges such as storm overflows, emergency overflows and septic tanks (DEFRA, 2006).

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3.17 Country information summary

Table 20 provides an overview of the data that were collected in the course of this study. For the various EU-15 countries, this table shows:

- the number of people that are not connected to sewer systems;
- the requirements that are set for the performance of small treatment plants at the national level;
- the number of plants with at least BOD and COD removal that were found during this study;
- the types of treatment systems that were reported.

Adding up all the data it is found that 11% of the EU-15 population, or 43.5 million people, are not connected to sewer systems. For seven of the 15 studied countries some form of requirement referring to the implementation and / or performance of small wastewater treatment plants was found, i.e. Austria, Belgium, Denmark, Finland, Germany, Netherlands and Sweden. Except for Austria, these countries have defined most of their territory as sensitive area.

A number of the EU-15 countries are still in the process of defining their sensitive areas, i.e. Great Britain, Greece, Italy, Portugal and Spain. This is probably the reason that requirements for small treatment plants were not found, although it should be mentioned that Italian law is recommending constructed wetlands as an appropriate solution for remote areas. France which has defined approximately 50% of its territory as sensitive is currently in the process of setting requirements at the municipal level.

A common feature encountered is a trend to consider on-site treatment systems as something undesirable, only acceptable because of the practical difficulties or the cost involved in the connection of 100% of the population to a sewer network, especially in places where households are scattered over a large area. However, when performance data are available, the efficiency of on-site systems was found to be good, enough to comply with most of the European regulations on wastewater discharge to the environment.

There is a general lack of data on the number of small treatment plants. The countries with the most accurate data on small plants (not including septic tanks or imhoff tanks) were found in Belgium, Finland, Germany, Luxembourg, Netherlands and Sweden. The total number of treatment plants with a high degree of BOD and COD removal (but not necessarily with nitrification and / or partial nutrient removal) in these countries amounts over 2.2 million. It should be mentioned that this figure includes also very basic systems like soil infiltration systems and wastewater ponds. Germany has the largest number with more than 1.7 million systems reported.

At this moment it is very hard to say to which extent the number of small treatment plants will grow. Belgium, Finland and Sweden are countries where a large number of treatment plants can be expected to be implemented in the coming years. Germany and The Netherlands have already made a huge afford in the last years and seem to be almost finished. The future situation in France, Great Britain, Greece, Italy, Portugal and Spain is unclear, since it is largely dependant on the outcome of the discussions around the sensitive areas.

Table 20. Summary of data gathered in the chapters on the EU-15 countries

Country	**Population (* 1000)**	**People and households not connected to sewer systems**		**Sensitive or non-sensitive area?**	**Are there treatment requirement for small treatment plants?**	**Number of decentralized plants with at least removal of BOD and COD, reported in this study**	**Types of treatment systems reported**
		%	**People (* 1000)**				
Austria	8,140.1	14%	1,140	Sensitive	Austrian law specifies requirements for new dwellings to construct treatment systems that with removal of settleable solids, BOD and COD and with nitrification	no exact numbers found, but reviewed statistics suggests that most not connected properties comply with requirements	Activated sludge systems, biological filters, rotating biological contactors, filtration systems, septic tanks
Belgium	10,396.4	10%	1,040	Sensitive	Yes, Flanders' law requires removal of settleable solids and BOD No treatment requirements were found for Wallonia	596 (Flanders) 3295 (Wallonia)	
Denmark	5,397.6	10%	540	Sensitive	Yes, four treatment classes specified with extensive removal of BOD (all), NH4 (2) and P (2)	no numbers found	
Finland	5,129.7	19%	975	Sensitive	Yes, treatment facilities should remove 90% of BOD7, >85% of total P, > 40% of total N, based on p.e. load	330,000	soil infiltration sites, closed containers, small packaged wastewater treatment plants
France	59,900.7	7%	4,193	> 60% sensitive	No, treatment requirements were found in this study. Treatment requirements should have been established at municipality level by the end of 2005	no numbers found	
Germany	82,531.7	5%	4,127	Sensitive	Yes, basically treatment systems should remove BOD and COD; local authorities may set requirements for nitrification, denitrification, P removal and hygienisation may be set in addition	1,760,000	Ponds, constructed wetlands, biological filter, moving bed bioreactors, fixed bed reactors, activated sludge systems, sequenced batch reactors, membrane bioreactors, sand filters

Country	Population (* 1000)	People and households not connected to sewer systems %	People (* 1000)	Sensitive or non-sensitive area?	Are there treatment requirement for small treatment plants?	Number of decentralized plants with at least removal of BOD and COD, reported in this study	Types of treatment systems reported
Greece	11,041.1	14%	1,546	> 25% sensitive	No treatment requirements were found in this study	no numbers found	
Ireland	4,027.7	44%	1,772	>75 % sensitive	No, treatment requirements were found in this study	Literature sources mention 350,000 individual systems, but these are mostly septic tanks	
Italy	57,882.0	27%	15,628	Only small parts are sensitive, according EC > 40% should be sensitive	No, but Italian law favours the use of constructed wetlands for treatment plants upto 200 P.E. They are defined as 'appropriate treatment'.	a few hundred constructed wetlands	natural systems like wetlands, ponds, reed beds or small trickling filters / biorotors, sequenced batch reactors, membrane bioreactors
Luxemburg	451.6	1%	5	Sensitive	No treatment requirements were found in this study	37	10 Activated sludge systems, 4 biological filters, 1 rotating biological contactor, 14 pond systems and 3 aerated ponds, 5 constructed wetlands
Netherlands	16,258.0	1.4%	228	Sensitive	Treatment is required, at least removal of BOD and COD; in specified areas nitrificiation, partial denitrification and / or partial P removal is due	33,000	sequenced batch reactors, biofilm reactors and activated sludge systems
Portugal	10,474.7	27%	2,828	Only 20% is sensitive, according EC > 40% should be sensitive	No treatment requirements were found in this study	no numbers found	
Spain	42,345.3	14%	5,928	Only small parts are sensitive, according EC > 80% should be sensitive	No treatment requirements were found in this study	no numbers found	

Country	Population (* 1000)	People and households not connected to sewer systems %	People (* 1000)	Sensitive or non-sensitive area?	Are there treatment requirement for small treatment plants?	Number of decentralized plants with at least removal of BOD and COD, reported in this study	Types of treatment systems reported
Sweden	8,957.7	14%	1,254	Sensitive	On-site systems should be 'more effective than sludge removal alone'. Further requirements are formulated at municipal level based on the environmental quality objectives that are laid down in the Environmental Code. The general tendency is to strive for at least 90% BOD and phosphorus reduction and 50% nitrogen reduction	> 200,000	source separating systems, chemical precipitation with sub-soil filter, sequenced batch reactors, biofilm reactors and activated sludge systems.
United Kingdom	59,673.1	4%	2,387	Only small parts are sensitive, according EC > 50% should be sensitive	No treatment requirements were found in this study	500-600	Septic tank, reed bed systems, rotating biological contactors
Total	382,607.4	11%	43,589				

4. State of wastewater treatment in the new member states of the European Union

This study has focused on the EU-15 states. However, during the course of the project the ERASM project team considered it important to also include some statistical information on the 10 new member states that entered the European Union on 1 May 2004. Therefore, this chapter contains some information on the state of wastewater treatment in the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia.

Table 21 shows the available data for Hungaria, Malta, Poland and the Czech Public as were found through Eurostat.

Table 21. Percentage of population connected to sewer systems and/or treatment systems for Hungaria, Malta, Poland and the Czech Republic according to Eurostat (Eurostat, 2006).

Water Boards	1970			1980			1990			1998			2001			2004		
	Sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.	sew.	wwtp	indiv.
Hungaria	28	21	15	40	48	17	43	47	19	48	54	18	52			-		
Malta	-			-			100			100			100			-		
Poland	-			-			-			55	89		-			-		
Czech Republic	56	59		65	69		73	71		74	86		75	91		-		

sew. = % of population connected to sewer systems, irrespective whether or not treatment follows
wwtp = % of population connected to sewer systems which includes subsequent wastewater treatment
indiv. = % of population connected to small-scale (individual) wastewater collection and treatment systems

Table 22 presents statistics for new member states given in the 2005 yearbook of the European Water Association. It should be noticed that Cyprus, Malta and Poland are not members of EWA and are not included in the yearbook.

Table 22. Percentage of population of the new EU member states that are connected to sewer systems and treatment systems according to the European Water Association (EWA 2005).

	Total population in million inhabitants (2002)	data for year	Waste-water quantity (10^6 m³/y)	% total population connected		Waste water treatment plants	% of annual wastewater quantity treated with		
				public sewer systems	public treatment plants		primary treatment	primary and secondary	primary, secondary and tertiary
Czech Republic	10.2	1999	576	77.4	72.5		2	31	67
Estonia	13.6	2003	119	72	71		1	25	71
Hungary	10.2	2003	514	59	51		2.6	68.3	29.1
Latvia	2.4								
Lithuania	3.5	2004	167	65	65		16.7	32.2	50.3
Slovak Republic	5.4	2003	131	55.9	50.5	390	9.7	79.1	11.2
Slovenia	2	2004	77.8	53	35.5		60	31.5	8.5

[a] numbers are for population in cities only

5. Types, performance and certification of small wastewater treatment systems

5.1 Introduction

This chapter contains an overview of small wastewater treatment systems used in the EU-15. It starts with a description of the conventional approach for wastewater handling in rural areas. Paragraph 5.3 provides an overview of small wastewater treatment systems for mixed household wastewater. Paragraph 5.4 describes the certification of small wastewater treatment plants at European level and in Belgium, Germany and The Netherlands.

5.2 Conventional approach for wastewater handling in rural areas

The conventional approach for wastewater handling of individual houses in rural areas is usually based on the treatment of black water in a septic tank. Grey wastewater – which relatively low polluted – is generally directly discharged. It should be noted however, within the context of this study, that most detergents will be discharged through grey water, which means that most detergents in non-sewered areas nowadays end up in the environment (soil or water).

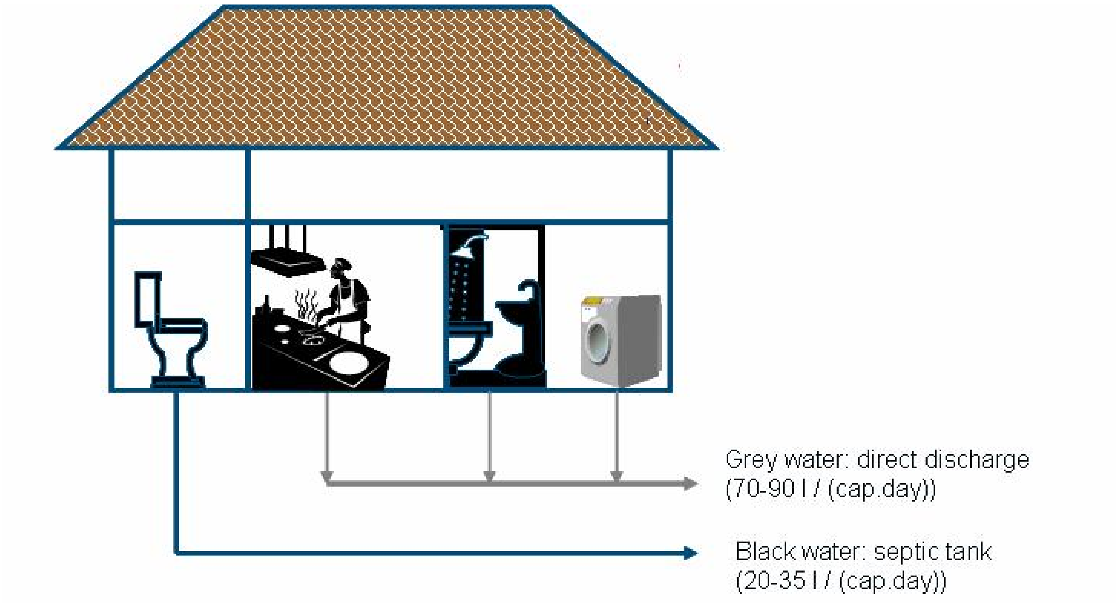

Figure 24. The conventional approach for wastewater handling of individual houses in rural areas is usually based on the treatment of black water in a septic tank and direct discharge of grey wastewater

A septic tank is a watertight tank below ground level, which receives excreta, flush water and other household wastewater (Figure 25). The liquid remains a short time in the tank and flows then to a soakaway pit, a drainfield or a nearby water body. Solids settle in the tank and are degraded by the biological activity in the septic tank. Digested solids build up in the tank and need eventually to be removed. The amount of sludge varies for each individual septic tank. Organic matter removal in septic tanks is variable and depends heavily on influent characteristics. COD and BOD removal efficiencies vary from 30 to up to 70% in some cases with averages around 50% (Philipp et al., 1999; Rahman et al., 1999; Stewart, 2005). Removal of other compounds (mainly suspended solids, nitrogen, phosphorous, and fecal coliform) is also variable. No reports on the removal of detergents in septic tanks were found.

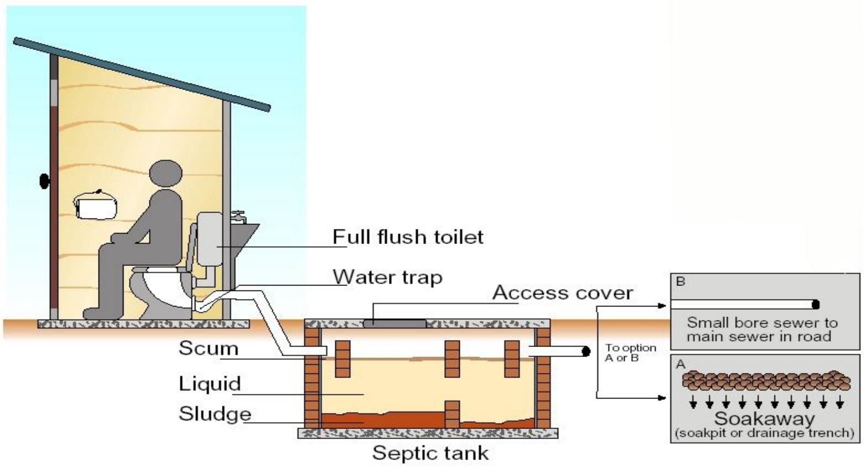

Figure 25. Septic tank with soakaway or connection to sewer (DWAF, 2002).

5.3 Small wastewater treatment systems for mixed household wastewater

5.3.1 Introduction

Small-scale treatment systems usually treat mixed household wastewater. The total amount of wastewater to be treated is approximately 125-150 liters per capita per day.

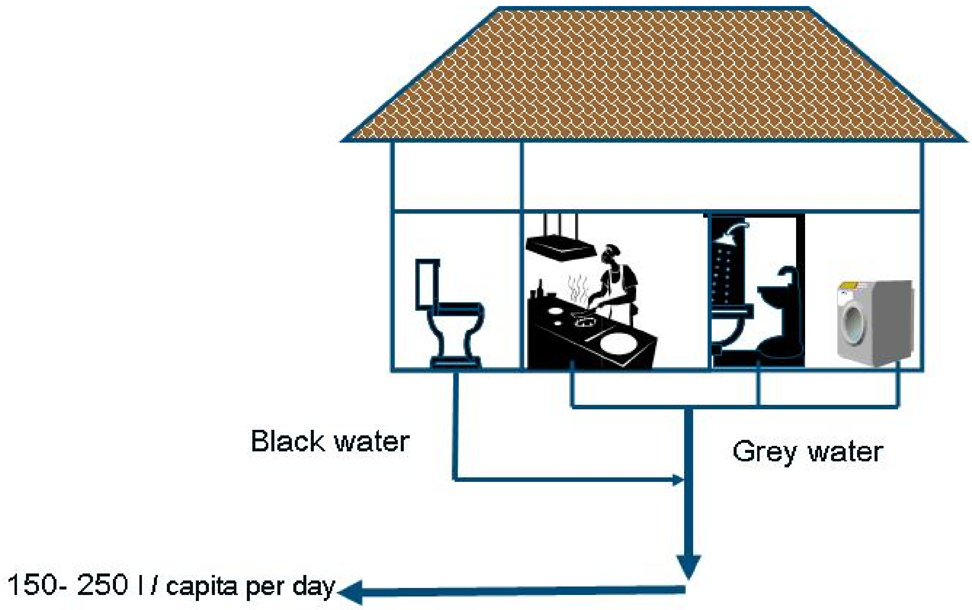

Figure 26. Mixed collection of black and grey wastewater in small wastewater treatment systems

In this section basic treatment systems applied for small-scale wastewater treatment will be described. Within the framework of this report, these treatment systems are classified in three categories as shown in Table 23. The description in the following paragraphs will focus on the systems that are feasible to provide secondary and tertiary treatment.

Table 23. Classification of small-scale treatment systems.

Primary treatment	Secondary treatment	Tertiary treatment
Removal of settleable solids and partial removal of COD	Removal of settleable solids, BOD removal and partial nitrification	BOD removal, nitrification and partial denitrification
Septic tank Improved septic tank Imhoff tank Sedimentation tank	Activated sludge systems Sequenced Batch Reactor Biological Filter Moving Bed Bioreactor Rotating Biological Contactor Constructed Wetland Filter beds Membrane bioreactors	Activated sludge systems Sequenced Batch Reactor Modified constructed wetland Membrane bioreactors

5.3.2 Activated sludge systems

These systems usually consist of a primary clarifier or septic tank, an aerated reactor and a sedimentation tank. Raw sewage is first brought to the primary clarifier where settleable solids are removed. Subsequently the water flows into an aerated reactor where air is bubbled into the wastewater. Substances that have a demand for oxygen are essentially removed here by the metabolic reactions (synthesis-respiration and nitrification) of the microorganisms in the system. Bacteria, fungi, rotifers, and protozoans are all present in the activated sludge. Separation and settling of activated-sludge solids occur in the subsequent sedimentation basin. Some of the settled biomass is then returned into the aeration basin while the rest is wasted. A block diagram of the process is shown in Figure 27.

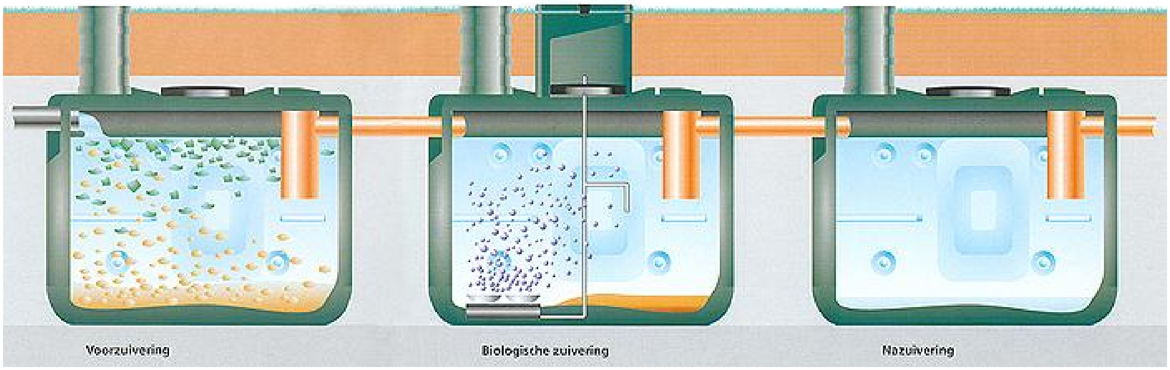

Figure 27. Sequence of small-scale activated sludge treatment plant consisting of primary sedimentation, aeration and final clarifier (www.aquaworld-biosystems.nl)

Variations of the activated sludge process include sequence batch reactors, moving bed bioreactors, biofilters and rotating biological contactors. Typical performance values for conventional activated sludge systems are presented in Table 24 although variations can be found depending on local circumstances (von Sperling and Chernicharo, 2005).

Table 24. Removal efficiency (%) in activated sludge systems (von Sperling and Chernicharo, 2005).

Parameter	Type of system	
	Conventional	Extended aeration
BOD	85-95	93-98
COD	85-90	90-95
Suspended solids	85-95	85-5
Ammonia	85-95	90-95
Nitrogen	25-30	15-25
Phosphorus	25-30	10-20
Coliforms	60-90	70-95

Figure 28. Activate sludge system from *Eternit* before (left) and after (right) installation.

5.3.3 Trickling filters / biological filters

These systems usually consist of primary sedimentation or a septic tank followed by a trickling or percolating filter (or biological filter) (Figure 29). A trickling filter is a filter in which pre-settled wastewater runs through a bed consisting of a bacteria-covered porous support material. The substrate moves through the film by mass transfer and the bacteria in the biological film remove the substrate. The film grows until there is either no available substrate or it is no longer able to withstand the shear force of the liquid. The solids and the treated wastewater are then piped to a settling tank in which separation occurs. Recirculation of the treated water is usually essential in order to increase the removal rate.

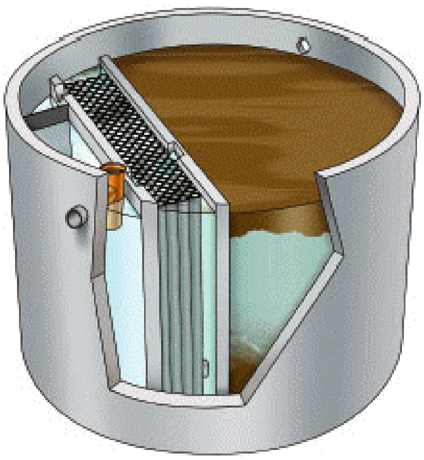

Figure 29. A biological filter reactor (http://www.epur.be)

Although the contact time between wastewater and the biofilm is only a few minutes to about an hour, much BOD removal is accomplished since it is transferred to the biofilm where oxidation and synthesis of new cells occur and the end products are washed back into the wastewater. Synthesis leads to growth of the biofilm which is eventually washed away by the wastewater flow itself and has to be recovered in a secondary sedimentation unit. BOD removal efficiency and the degree of nitrification achieved in trickling filters can very depending on the type of system and on the kind of filling material used (Table 25). COD removal efficiency values are expected to be slightly higher than for BOD. Removal of suspended solids is clearly poor as long as trickling filters are intended to treat pre-settled wastewater.

Table 25. BOD removal efficiency (%) and degree of nitrification achieved in different types of trickling filters (after Arceivala, 1998).

Type of system	Parameter	
	BOD removal (%)	Degree of nitrification
Low-rate filters	80-85	High
High-rate (stone media) filters	65-85	Limited
High-rate (plastic media) filters	65-85	Limited
Roughing filters	40-65	Nil

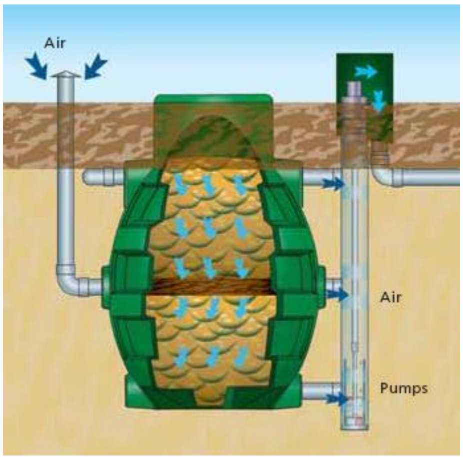

Figure 30. Sub-surface biofilter process (*Biorock*, Wet&Pure Technology BV).

5.3.4 Sequenced batch reactors

Sequenced batch reactor (SBR) systems are also based on the removal of biodegradable organic material and nutrients by activated sludge. In contrast to activated sludge systems, both aeration and sedimentation take place in the same reactor. The sequence batch reactor is operated in several operating modes.

Figure 31 shows the steps involved in the SBR operating cycle. During the first step the reactor is filled with influent and the contents are mixed. The second phase consists of aeration resulting in biodegradation and nitrification. When the reaction phase has reached completion, mixing and aeration are discontinued and quiescent settling takes place. The treated supernatant is then removed from the reactor. The excess biomass can be removed at any point during the cycle.

Treatment performances achieved in SBR may be higher than in conventional activated sludge systems because the sludge age can be increased considerably, and there have been technological improvements in the effluent withdrawal devices and the use of automated control by microprocessors. In the past years, in view of the growing concern with the discharge of nutrients in surface waters, SBR have been adapted to provide nitrification, denitrification, and biological phosphorous removal (von Sperling and Chernicharo, 2005).

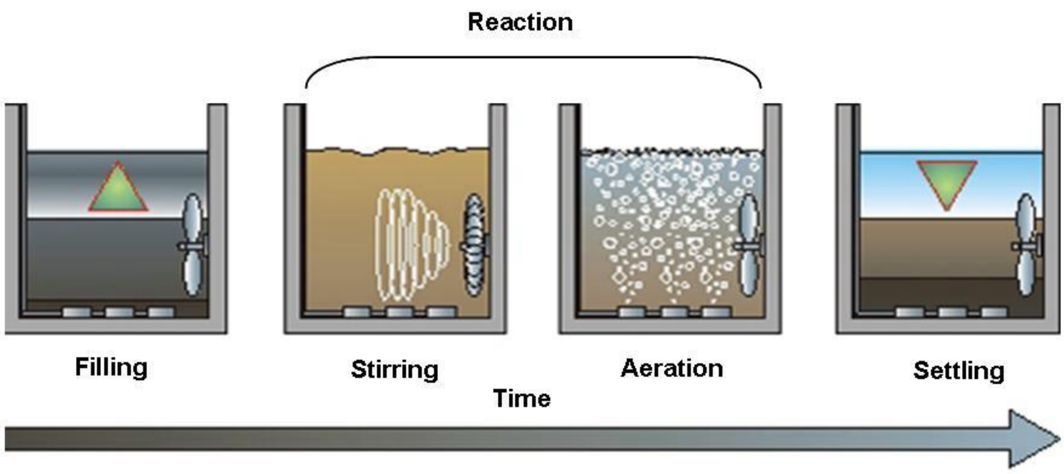

Figure 31. Sequenced batch reactor operating cycle: filling, mixing, aeration, sedimentation and effluent removal (http://www.dywidag-aquaschutz.de/).

5.3.5 Moving Bed Bio Reactors (MBBRs)

These systems usually consist of primary sedimentation or a septic tank followed by a moving bed bioreactor system (Figure 32). In moving bed bioreactors, bacteria are grown on particles of a medium, such as plastic carriers. The carriers are fluidized by the upward flow of the wastewater through the reactor. This flow is combined with air to provide for oxygen. A minimum fluidization velocity is required in order to achieve the appropriate bed expansion. This velocity depends on several factors including the size, shape, density and porosity of the particles and the density and viscosity of the liquid. High shear forces exist in the reactor, these limit the growth of the bacterial film on the media, which in turn leads to better mass transfer between the film and the liquid. MBBR are systems that can achieve high treatment efficiency and conform to the most stringent regulations, offering flexible configuration options that can be even operated in a fully automated mode with relatively simple maintenance procedures. They can be used in decentralized schemes because they have a small footprint area and the need for a buffer zone is reduced (Figure 33).

Figure 32. Moving Bed Bio Reactors (http://www.mall.info)

Figure 33. Moving Bed Bio Reactors can be used for decentralized wastewater treatment.

5.3.6 Rotating biological contactors

These systems consist of a primary sedimentation unit or a septic tank followed by a rotating biological contactor (RBC) treatment system. RBCs are also biofilm processes. Bacteria are grown on a medium, in this case rotating discs. Through the rotation of the discs bacteria receive the oxygen that they require for oxidation of organic material and for nitrification. Pilot plant RBCs have been used for post-treatment of sewage (after primary and secondary treatment), especially for the removal of pathogenic microorganisms and ammonia. Ammonia concentration can be reduced by almost 70% and pathogens by 99.9% (Tawfik *et al.*, 2002).

Figure 34. Rotating biological contactor (http://www.pmtwater.com).

5.3.7 Membrane Bioreactor

The Membrane Bioreactor or MBR is a relatively new reactor that combines a conventional activated sludge process and a membrane filtration step. Essentially, the membrane system replaces the solids separation function of secondary clarifiers in a conventional activated sludge system. Although membrane reactor were originally developed for industrial purposes and large municipal wastewater treatment plants, various manufacturers nowadays supply membrane stacks that can be placed in small treatment plants.

Ultra filtration membranes (indicative pore size 0.1 – 0.4 µm) are the most applied type of membranes. The membranes can either be submerged or be installed as a separate unit. Submerged membranes are most common and are placed into the bioreactor. A vacuum is applied downstream of the membranes to allow for the solid/liquid separation process to occur. The vacuum draws the treated water through the membranes. Air is introduced into the bioreactor to scour the membranes and drive the biological treatment. The scouring action transfers rejected solids away from the membrane surface and prevents fouling

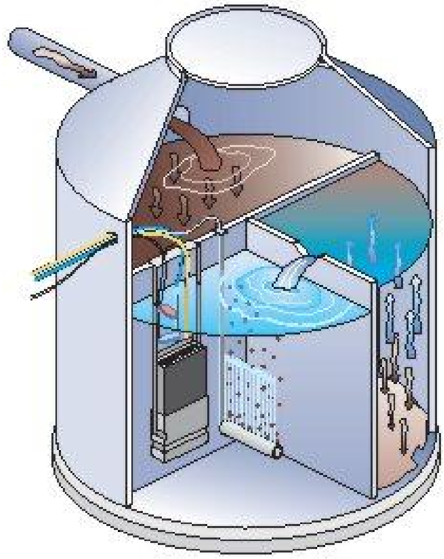

Figure 35. MembraneClearBox of the German company Huber, the first certified small size membrane bioreactor in Germany (www.huber.de)

The MBR has some important advantages compared with conventional activated sludge systems.

- It produces a high quality effluent, because the membranes withhold all biomass and other suspended solids.
- The design of the wastewater treatment system can be compact, because the micro organisms in the bioreactor can be maintained at a concentration 4-5 times higher than in conventional systems. A clarifier, which may be a space-consuming tank, is not required.
- The MBR can operate at a low F/M ratio, i.e. the feed of organic substance per quantity of activated sludge per time unit. This results in a high mineralisation of the sludge. In conventional systems 1 kg COD will result in about 0,3 -0,4 kg of biomass. With MBR systems 1 kg COD is converted to 0 - 0.2 kg biomass.

Typical effluent values for membrane bioreactors treating domestic wastewater are shown in Table 26:

Table 26. Typical effluent values for membrane bioreactors treating domestic wastewater (based on: Jefferson et al, 2000; STOWA, 2002, 2004; various Internet sources)

BOD	< 2 – 5 mg/L
Total suspended solids	< 1- 5 mg/L
NH_4-N	< 0.5 -2 mg/L
Turbidity	< 0.2 -4 NTU
Fecal Coliform	< 10 CFU/100 mL

5.3.8 Constructed wetlands

A constructed wetland is basically a filtration bed planted with emerging macrophytes. The system makes use of filtration, settling, and bacterial decomposition in a lined wetland (Figure 36). There is a wide variety of design features regarding constructed wetland systems with differences in flow pattern, the type of substrate (soil, sand, gravel), one-stage, multi-stage and hybrid systems and used wetland vegetation.

Macrophytes are the conspicuous plants that dominate wetlands, shallow lakes, and streams. Macroscopic flora includes the aquatic angiosperms (flowering plants), pteridophytes (ferns), and bryophytes (mosses, hornworts, and liverworts). An aquatic plant can be defined as one that is normally found growing in association with standing water whose level is at or above the surface of the soil. Standing water includes ponds, shallow lakes, marshes, ditches, reservoirs, swamps, bogs, canals, and sewage lagoons. Aquatic plants, though less frequently, also occur in flowing water, in streams, rivers, and springs.

This paragraph will describe the general features of constructed wetlands. In the article 'Design Criteria for a constructed wetland' that is given in Appendix B more details on the design are provided.

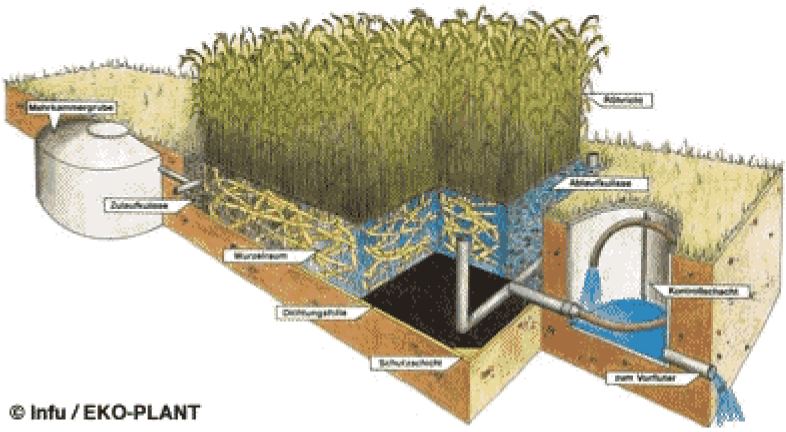

Figure 36. Lay-out of a small-scale constructed wetland (http://www.ekoplant.de).

There are two main types of constructed wetlands: horizontal- and vertical-flow wetlands (VF) (Figure 37).

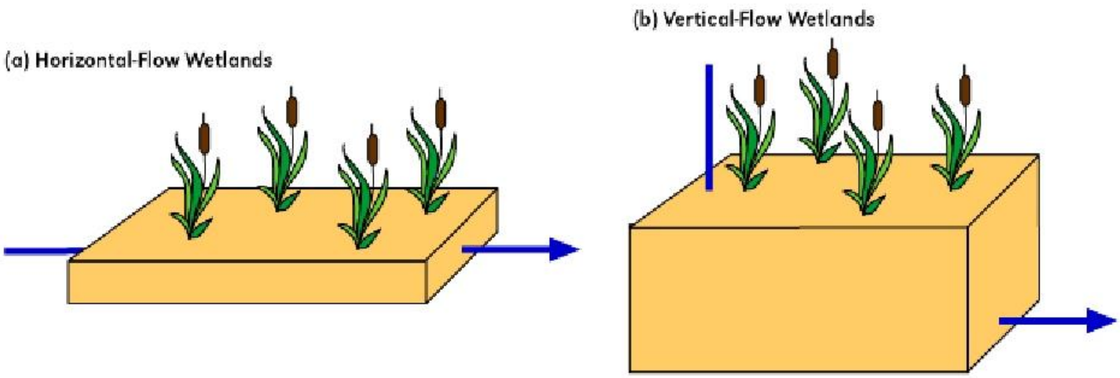

Figure 37. Types of constructed wetlands.

With respect to flow patterns an important difference lies between surface flow or freewater surface system (FWS) and sub surface flow (SF) wetland systems (Figure 38). The FWS uses settling as the major treatment mechanism. In addition, a passive type of filtration occurs between the plants and percolation into the upper part of the root zone. They are often very densely vegetated with floating or rooted emergent plants (Blanco *et al.*, 2000).

In SF systems the effluent moves through the medium below the surface. Keeping the effluent level below the gravel surface prevents the effluent from coming into contact with people, and prevents mosquitoes from breeding. It also keeps the water level high enough to sustain plant growth. The system requires more space than a surface flow system and is more expensive, but provides a larger treatment area. In comparison they generate less odor and freezing problems. Options exist to reduce freezing risks. Sub surface flow systems, also referred to as 'root zone systems', 'reed bed filter systems' or 'rock reed filters' are channels or trenches designed with the objective of secondary or advanced levels of treatment. Primary treated wastewater (after a septic tank or sedimentation tank) is distributed over the wetland through sub surface drainage pipes and is filtered through the sandy or rocky medium. The effluent is removed through drains. Here the major treatment technique is filtering. Some of the suitable substrates for filtration include sand, gravel, or a mixture. Plants grow in this saturated substrate and the wastewater filters through the root zone. The planted root-zone acts as a biofilter, trapping suspended solids, organic matter, nutrients, and pollutants. A principle difference in sub surface flow wetlands is found in the flow direction: both horizontal flow and vertical flow systems are applied. The influent dose might also be continuous or intermittent. Vertical flow filters are in most cases operated with intermittent loading in order to enhance oxygen supply to the root zone of the bed thus enhancing aerobic degradation and nitrification.

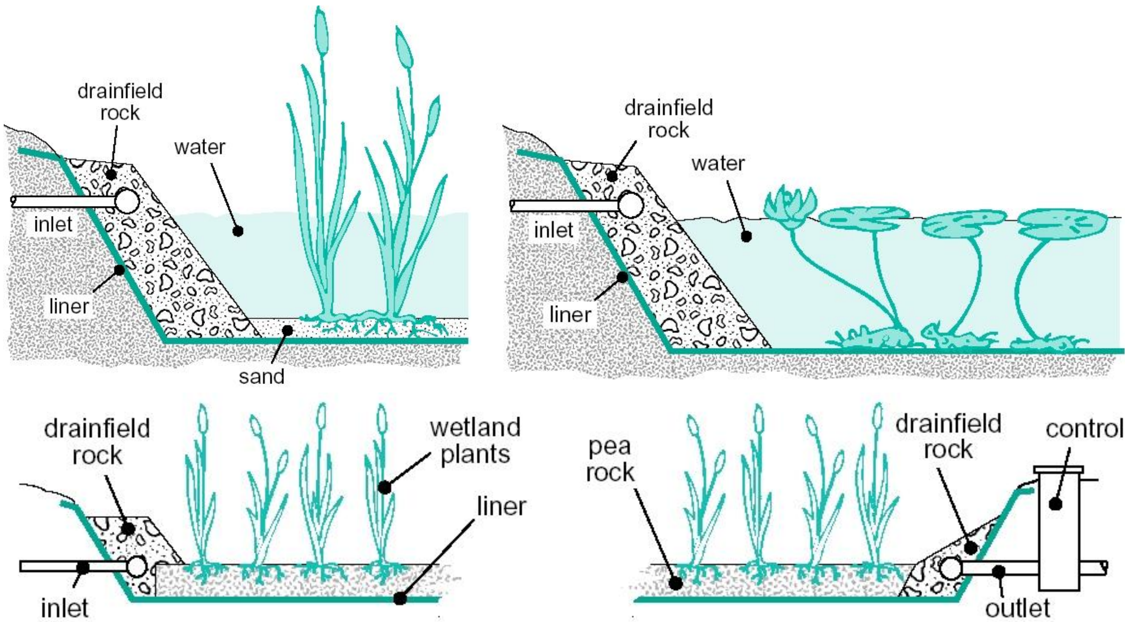

Figure 38. Constructed wetland types. Top: two types of surface flow systems, bottom: subsurface flow system inlet side and outlet side (Gustafson *et al.*, 2002).

5.3.9 Performance

Removal efficiencies achievable in certified systems should always be above the minimum requirements set by the standards. A thorough screening of the performance of different IBA systems was performed since 1999 by the company Agrotransfer B.V. (http://www.agrotransfer.nl). For this project, 15 different IBA-systems from private households, agricultural businesses and clusters of houses were selected and intensively followed in 21 locations in Flevoland´s countryside. Data gathered include

§ Influent and effluent quality (> 2500 complete analyses)

- Investment and operation costs
- Role of end users and other factors on the practical performance of the systems
- Operation and maintenance
- Reuse of treated wastewater

It was concluded that IBA systems are a safe and realistic alternative to sewerage due to their high treatment efficiency (> 85%) and acceptable costs. Results were presented in a report by the name “IBA´s in beeld”. Results reported by different companies seem to confirm that IBA systems are efficient and reliable (Table 27) and produce varying effluent characteristics in order to comply with the certification requirements (Table 28).

Table 27. Examples of removal efficiencies (in %) achieved by some of the IBA systems in the Dutch market[a].

Parameter	Akanova[a]	Multivis[b]
Biochemical Oxygen Demand (BOD)	90 – 95	98.9
Chemical Oxygen Demand (COD)	95 – 98	93
$N\text{-}NH_4^+$	70 – 80	94
N total	98 – 99	78
P total	70 – 85	
Suspended Solids	90 – 98	93

[a] http://www.akanova.nl/water.htm, [b] http://www.multivis.nl/frame-home-uk.htm

Table 28. Effluent characteristics (mg/L) from IBA systems[a].

Parameter	Gozon[a]	Multivis[b]	Biorock[c]
Biochemical Oxygen Demand (BOD)	< 40	3.3	< 10
Chemical Oxygen Demand (COD)	< 200	51.9	< 50
$N\text{-}NH_4^+$	< 4	0.22	
N total	< 60	15.1	
Suspended Solids	< 60	13	< 10

[a] http://www.gozon.nl, [b] http://www.multivis.nl/frame-home-uk.htm, [c] http://www.wetpuretechnology.com

5.4 Certification of small wastewater treatment plants

5.4.1 European certification

The issuing of a European certificate is under development for 10 years now. The formal vote on this standard was made mid 2005 and the standard will probably be legally binding by the start of 2006. A transition period of at least one year between the enforcement of pre-existing national standards and the new European standard is foreseen. From December 1st, 2005 the standard 12566-1 already applies for the construction of septic tanks. The standard for advanced systems, the 12566-3, is also ready which means that all small wastewater treatment will have to have European certification per by end of July 2008. The European certificate will be legally binding, which means that all systems in or entering the market will have to have a certificate and comply with the European standard.

The European certification sets i) a standard for the quality of the used materials and the system construction and ii) it requires that the system is tested by a recognized laboratory. An important point is that the European certification does not set effluent or performance requirements and does not define treatment classes. The laboratory should measure the treatment performance according a fixed protocol. The results are published in an open report that should be available to the public and provides information on the performance of the system.

5.4.2 Belgium

Certification process and requirements

The Belgian certification of small wastewater treatment plants and septic tanks anticipates on the European certification standards EN 12566-3 and EN 12566-1. It provides manufacturers to already comply with these future standards.

If a small system is certified is receives the product compliance brand BENOR. BENOR is owned by the Belgian Institute for Normalisation (BIN). BIN has authorized Certipro (www.certipro.nl) to do the Belgian certification for small wastewater treatment plants and septic tanks. Certipro also has a European notification for this purpose (nr 1476).

Certipro will evaluate the small wastewater treatment plant intensively during one year following EN 12566-3. The water tightness, capacity, treatment performance and the sustainability of the materials and construction features will be evaluated. In addition the certification demands the supplier to establish an internal product control system. The internal control system should enable the manufacturer to produce all products in the same way as the approved prototype.

Certified systems

There are 3 suppliers that have BENOR certification for 8 systems in total. Table 29 provides a list of certified compact systems.

Table 29. BENOR certified small wastewater treatment plants in Belgium

Specific reactor name	Supplier / producer	Type of system
ETERNIT EP-6 microstation	Eternit NV	Activated sludge
Micro-step, gamma 4 IE, 6 IE, 8 IE	Roth Industries GmbH & Co, Bischofswerda (Germany)	Activated sludge
BelleAqua SAF 1 - 6 IE	BelleAqua bvba	Biofilter
BelleAqua SAF 7 - 12 IE		
BelleAqua SAF 13 - 20 IE		
BelleAqua SAF 21 - 30 IE		
BelleAqua SAF 31 - 40 IE		
BelleAqua SAF 41 - 50 IE		

Figure 39. Installation of a BelleAqua SAF 1 - 6 IE with effluent infiltration (www.belleaqua.be)

5.4.3 Germany

Germany is the country with most small wastewater treatment plants in Europe. It also has a very large list of suppliers of various systems. According to the German Wastewater Ordinance the effluent quality of individual treatment plants needs to comply with maximum values for COD and BOD_5 of 150 mg/l and 40 mg/l respectively. The German Institute for Construction Technology (Deutschen Instituts für Bautechnik, DIBt) has set up a division of different classes for prefabricated small wastewater treatment plants (LfW 2005):

1. Installations with carbon elimination	Class C
2. Installations with additional nitrification	Class N
3. Installations with additional denitrification	Class D
4. Installations with additional phosphorous elimination	Class C, N, D, +P
5. Installations with additional hygienisation	Class C, N, D, +H

Class C meets with the minimum requirement of the Wastewater decree. When offering a treatment system to the market, the DIBt will test the installation thoroughly and grant one of the classes to the system. Also for the non-prefabricated system such as reed bed filters and pond systems legislation exists: ATV-Arbeitsblatt A262 and DWA-Arbeitsblatt A201 respectively.

Certified systems

In Table 30 different small treatment systems are compared based on the treatment class they could belong to. Appendix C provides an overview of almost all certified systems and their suppliers. Where information was available also the treatment class of the system is provided.

Table 30. Different small wastewater treatment systems and their obtainable effluent quality. x: Standard, (x): Only with special way of measuring or operation, ((x)): Only very limited

	Reachable effluent quality				
	C	N	D	+P	+H
Wastewater pond	x	(x)	((x))		
Constructed wetland	x	(x)	((x))		
Biological filter (trickling filter)	x	(x)			
Contact system	x	(x)			
Aerated fixed bed reactor	x	(x)			
Activated sludge system	x	x	(x)		
Sequenced batch reactor	x	x	(x)		
Aerobic membrane bioreactor	x	x	(x)		x
Sand filter	x				
Complementary phosphorous precipitation				x	
Seepage into aerated soil					(x)

5.4.4 The Netherlands

Certification process and requirements

The certification of small treatment plants or IBA systems in the Netherlands was an initiative of IBA suppliers back in 1998 supported by the Ministry of Housing, Spatial Planning and the Environment (VROM). The certification requirements were put in place with the help of experts from the market, research institutions, and the government. The panel decided to classify IBA systems in three classes (Table 31). The classification in these three classes and the certification procedure is not yet included in any legislation.

Table 31. Classes of small treatment plants (IBA systems) for certification purposes. Effluent requirements in mg/L from 24-h composite samples.

Parameter	**Class I**	**Class II**	**Class IIIa**	**Class IIIb**
Biochemical Oxygen Demand (BOD)	< 250	< 30	< 20	< 20
Chemical Oxygen Demand (COD)	< 750	< 150	< 100	< 100
$N\text{-}NH_4^+$			< 2	< 2
N total			< 30	< 30
P total				< 2
Suspended Solids	< 70	< 30	< 30	< 30

The certification process has three components, namely: (a) product test to see if the system really works, (b) product certification in terms of the sustainability of materials and construction system, and (c) process certification to guarantee the proficiency of the provider. The certification is coordinated and monitored by KIWA NV (http://www.kiwa.nl). The tests are executed by specialised laboratories. At present only one laboratory is authorized to certify IBA systems in The Netherlands, i.e. Van Hall Institute (www.Ibahelpdesk.nl).

Certified systems must guarantee the required effluent standards under regular conditions and under “stress” circumstances. The test period lasts 6 months during which standard wastewater is administered to the system according to a fixed daily pattern of low and high loads at different hours of the day. Stress tests are also carried out during this period. For this purpose several tests have been designed:

- In the ‘bathtub test’ 200 liter of water is discharged to the system within 3 minutes;

- Another test simulates the discharge of a washing machine to the system;
- The '24-h power cut test' examines whether the system is able to recover within 5 days after the power cut;
- The 'holiday stress test' examines whether the system is able to recover from a period without any wastewater load within 5 days;
- The 'party test' simulates a peak load of 6 h.

The systems are certified for a life time of 20 years. There are currently regulations to certify septic tanks, compact systems, and down flow helophytes filters, together with some construction regulations in concrete and metal.

Certified systems

There are a number of systems already certified in the Netherlands, most of them within classes II and III. Table 32 provides a list of certified compact systems. These systems, included within the category of "compact" systems are mostly aerobic systems based on the activated sludge process (Figure 41 and Figure 40). Other options are based on the trickling filter process in which micro attach to a matrix of porous media to provide biological degradation of the organic compounds present in sewage. These systems can be optimized by providing additional mechanical aeration (Figure 30).

Table 32. Certified IBA compact systems (BRL K10004) in The Netherlands

Specific reactor name	Supplier / producer	Type of system	IBA Class
Upoclean, Biosub	AkaNova	Activated sludge	II, IIIa
Bever Combi Compact, Bever IIIa	Afmitech Friesland	Activated sludge	II, IIIa
SuperCompact klasse II, BCI klasse IIIa	Boralit NV	Activated sludge	II, IIIa
ETERNIT EP-6 microstation	Eternit NV	Activated sludge	II, IIIa
Lutra Compact Systeem	Lutra Milieusystemen BV	Biofilter	II, IIIa
unknown	Watertechnology BV (Wavin)	*unknown*	II, IIIa
Biorock	Wet & Pure Technology BV	Biofilter	II

Figure 40. Activated sludge systems of *Boralit NV*

Figure 41. Compact system based on the activated sludge process of *Afmitech Friesland*

Table 33 provides a list of 3 certified suppliers of vertical-flow constructed wetlands. Systems based on the use of constructed wetlands are also popular and there are several providers of such systems in The Netherlands (Figure 42).

Table 33. Certified vertical-flow constructed wetlands (BRL K10005) in The Netherlands

Supplier / producer	Type of system	IBA Class
BrinkVos Water BV	vertical-flow constructed wetlands	IIIa, IIIb
Coöperatie IBA Installateur	vertical-flow constructed wetlands	IIIa, IIIb
Lareco Nederland BV	vertical-flow constructed wetlands	IIIa, IIIb

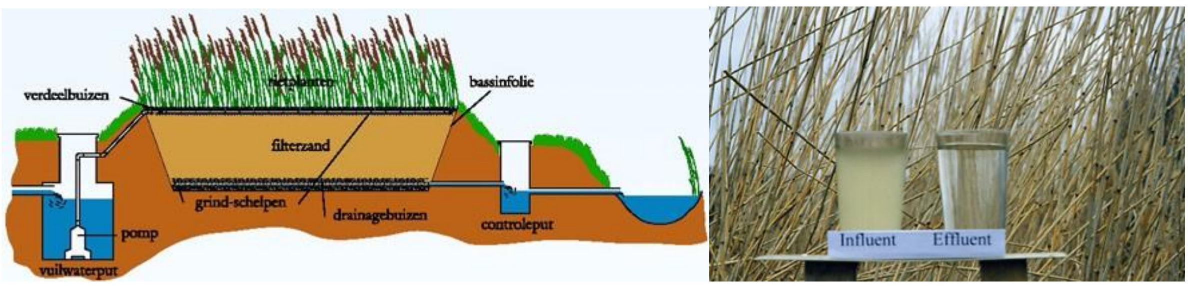

Figure 42. Left: Diagram of certified constructed wetlands systems (*Brinkvos*). Right: comparison between influent and effluent showing high removal of suspended solids.

Links

Certifications: http://www.kiwa.nl/KiwaCertification.asp?id=2098
General description IBA systems: http://www.ibahelpdesk.nl

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Appendix A – Situation of sewerage connection and individual treatment systems in The Netherlands (RIONED)

	Plots not connected		Sanitation through				# municipalities	
	Total 2002	Total after complete sanitation	present situation (i.e. septic tank)	IBA1	IBA2	IBA3	Total	offering full care of IBA's
Water Boards								
W.B. Amstel,Gooi en Vecht	5,342	289	0	92	57	140	25	10
W.B. Delfland	5,250	240	0	0	0	240	12	0
W.B. Hollands Noorderkwartier	10,000	8,078	6,718	0	1,122	238	44	3
W.B. Rijnland	6,788	1,750	0	1,300	200	250	42	14
W.B. Schieland/Krimpenerwaard	950	100	50	0	50	0	13	0
W.B. De Stichtse Rijnlanden	1,849	100	40	20	0	40	27	8
W.B. Aa en Maas	7,470	279	120	10	0	149	29	-
W.B. Brabantse Delta	5,420	3,032	759	1,525	409	339	21	8
W.B. De Dommel	3,313	160	0	0	48	112	33	0
W.B. Fryslân	16,336	12,500	0	12,130	370	0	31	-
W.B. Groot Salland	8,200	2,100	1,560	500	10	30	13	0
W.B. Hollandse Delta	5,890	1,750	1,738	0	0	12	42	1
W.B. Hunze en Aa's	7,157	1,800	300	0	300	1,200	24	14
W.B. Limburg	7,000	750	50	0	0	700	47	26
W.B. Noorderzijlvest	5,027	3,182	0	1,035	2,147	0	20	17
W.B. Reest en Wieden	1,674	745	0	0	478	267	13	8
W.B. Regge en Dinkel	12,500	3,000	300	2,400	0	300	17	-
W.B. Rijn en IJssel	9,800	1,500	1,000	0	125	375	38 [b]	14
W.B. Rivierenland	7,685	250	180	35	35	0	38 [c]	20
W.B. Vallei en Eem	4,650	75	0	0	75	0	23	1
W.B. Velt en Vecht	2,788	922	0	646	0	276	9	8
W.B. Veluwe	2,664	1,800	300	0	300	1,200	19	14
W.B. Zeeuwse Eilanden	3,010	2,400	2,300	25	50	25	10	0
W.B. Zeeuws-Vlaanderen	2,761	1,980	1,840	0	0	140	3	3
W.B. Zuiderzeeland	4,150	4,165	3,115	0	1,050	0	6	6
Netherlands	147,674	52,947	20,370	19,718	6,826	6,033	599 [d]	175

a Reference Date: January 1, 2004; IBA = installation for individual treatment of wastewater. b Following reallocation on January 1, 2005 in Rijn and IJssel, the number of municipalities has decreased from 38 to 22. c On January 1, 2005, The Alm and Biesbosch Water Board has been integrated in Rivierenland. d Municipalities sometimes come under more than one water board, which explains why the total exceeds 467.

Appendix B Elimination of detergent ingredients in domestic and municipal sewage treatment plants

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Almost 70% of the communal sewages in the EU is purified in municipal sewage treatment plants. The households not connected to a municipal sewage network for technical and/or economic reasons, have to process their waste waters by private management (EU Council Directive 91/1271/EEC). Particularly in rural areas small-scaled domestic sewage treatment units have to perform the sewage purification task which has to be in line with legal limits of effluent discharges into receiving waters.

The biodegradation and elimination of detergent ingredients in municipal sewage treatment plants has been investigated comprehensively for a long time while corresponding data are missing for small-scaled domestic plants. To supplement the existing knowledge about the environmental fate of detergent ingredients in those units, a monitoring study in two different small-scale (6 cap) domestic sewage treatment plants, i.e. a trickling filter and a plant-based sewage treatment system was conducted.

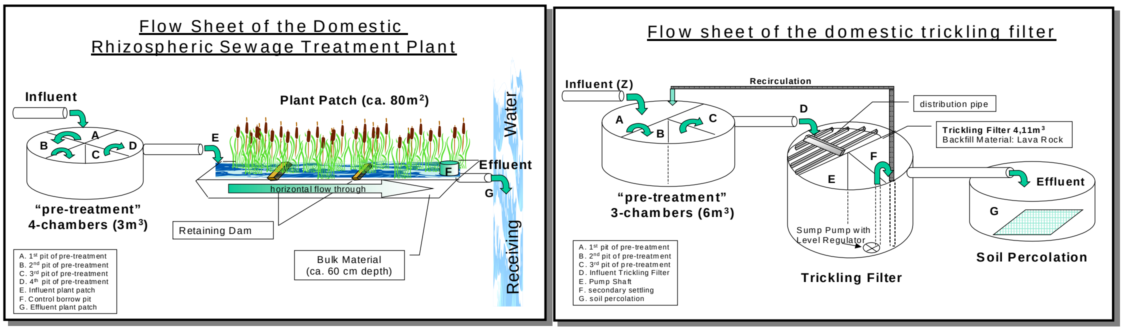
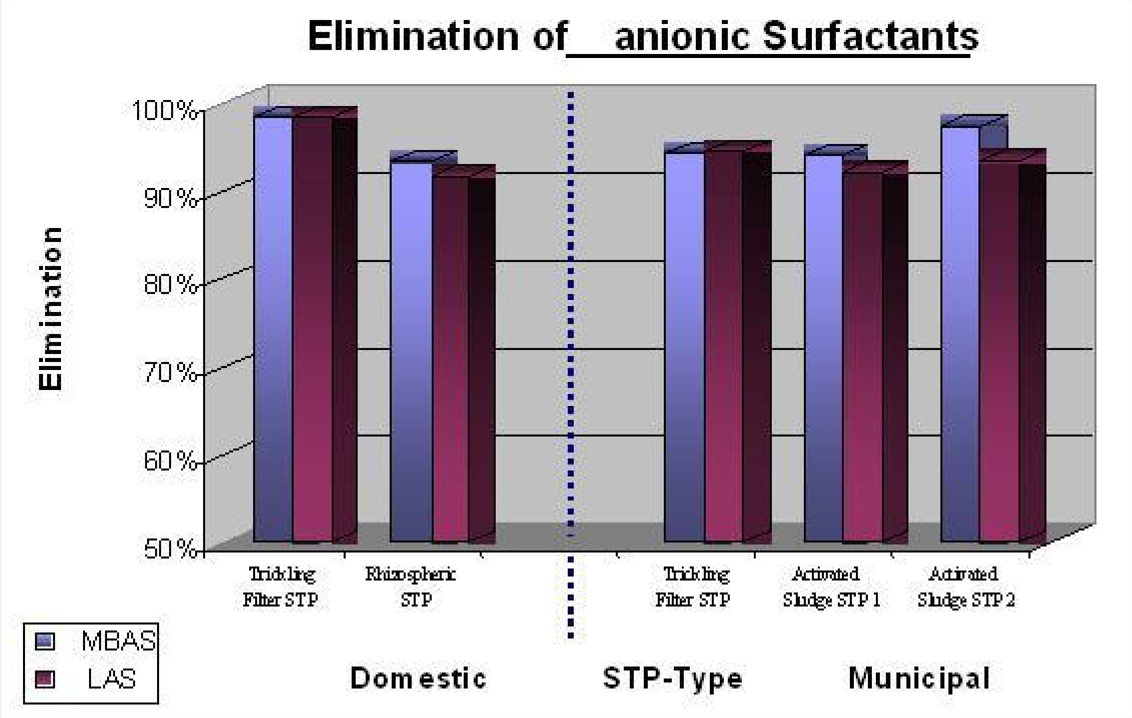
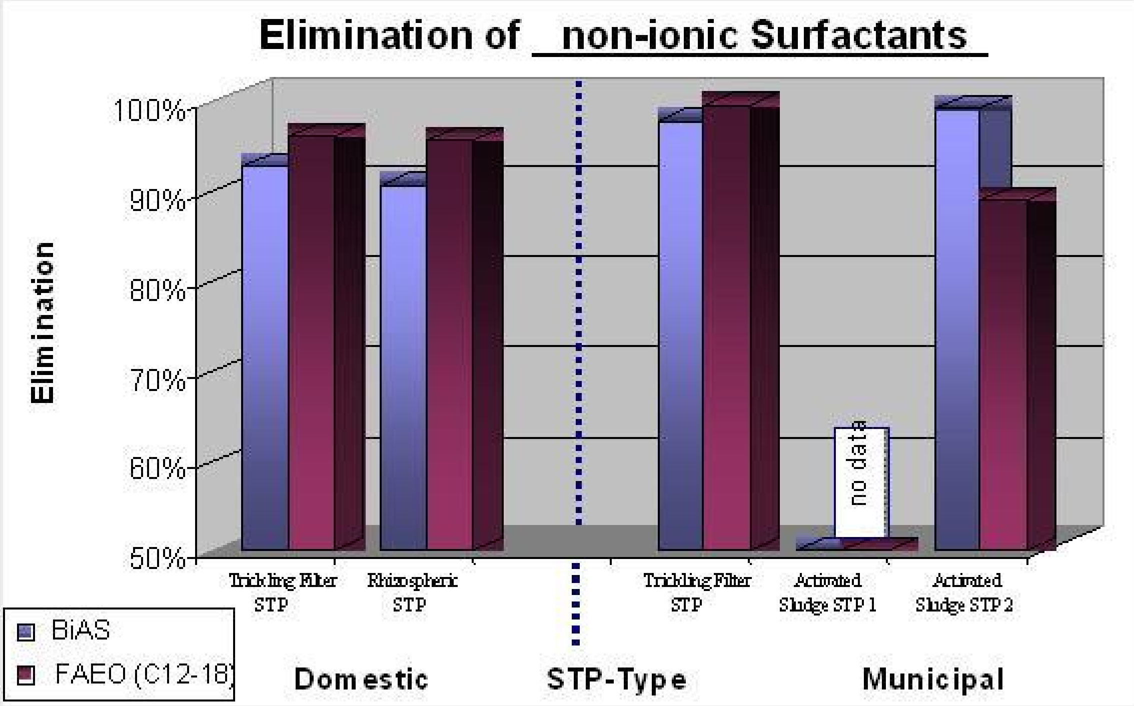


Figure 43. Flow sheets of the two investigated small-scale domestic sewage treatment plants

The elimination extent of several detergent ingredients (e.g. anionic and ionic surfactants, borate, fluorescent brightener) and pertinent water quality parameters were measured and were compared with data obtained in medium and large scale (4.300-65.000 cap) municipal waste water purification plants (activated sludge & trickling filter systems). While the carbon removal efficiency was similar in all plants (> 87% COD), the N-removal exhibited high variations depending on the plant type. Both, anionic and nonionic surfactants were extensively eliminated in all treatment systems. For anionic surfactants (MBAS), an elimination of 92% and 96% was determined in the plant-based sewage treatment system and in the trickling filter, respectively, while 94-97% elimination occurred in municipal plants. Nonionic surfactants (BIAS) were eliminated in the range of 95- 97% in the small-scaled units and 88-99% in the larger scale plants. The study confirmed that detergent-based surfactants are comparably well bio-eliminated in domestic and municipal waste water treatment plants.





Elimination of detergent ingredients:

High surfactant removal was observed in both, municipal and domestic STPs. In domestic STPs, anionic surfactants (MBAS) were eliminated to a degree of >93% while elimination of non-ionic surfactants (BIAS) exceeded 91%. Calculations based on the real detergent consumption of the residents indicated even higher degrees of elimination at levels of 97-99%.

Appendix D – Suppliers and types of certified small wastewater treatment systems in Germany

Tabel C1. Certified **sequence batch reactors** and their suppliers (bron: http://www.klaeranlagen-vergleich.de/)

Supplier	System name	Treatment class	Supplier	System name	Treatment class
ABA	ABA Bioquick		Rhebau	AQUAstar	
ATB	ATB Aquamax	C, Ex-Schutz	Rotaria	Klärmeister	
	(downloadlink)		Umwelttechnik Nord	Klärmax	
BBW	BBW SBR-Aquamax		Uponor Klärtechnik GmbH	Uponor Nachrüstsatz BatchPLUS	C,N,D,P
	BBW				
	KLÄR Kit			Uponor Komplettanlage	C,N,D,P
Biwater IBO GmbH	Biwater IBO GmbH				
	BiPur 4-50 EW		UTP	Klärofix	
Domotec	Domotec Kunststoff-kläranlage		Westberg	Westberg System	
Graf	Klaro		Wasser Loewe GmbH	AQUA-SIMPLEX	
	AquaSimplex				
Jung	Oxynaut				
Kessel GmbH	INNO-CLEAN		Zapf GmbH	Klaro	
Kordes	AQUA-SIMPLEX				
Nordbeton	Bubbler Twister				
REWATEC	MONOfluido				
	MONOfluido SKS (Schlamm-Kompostierungs-System)				
	FLUIDO				

Tabel C2. Certified **fixed bed reactors** and their suppliers

Supplier	**System name**	**Treatment class**	**Supplier**	**System name**	**Treatment class**
Delphin	Kompaktkläranlage im Kunststoffbehälter		BBW	Tropfkörper	
EUSAG	BIO-TOP	C	Kordes	BIO-CLEAR	
EvU	WBA 4-53 EW		Nordbeton	Biopott (8-31 EW)	
Kordes	BIO-FLOW			Klärpott (5 / 9 EW)	
			Mall GmbH	Tropfkörperanlagen	
Uponor Klärtechnik GmbH	Uponor Nachrüstsatz 3K PLUS	C, N, D	Wasser-Loewe GmbH	BIO-CLEAR	
_	Uponor Komplettanlage				
Wasser-Loewe GmbH	BIO-FLOW				
Zapf GmbH	Logo (downloadlink)				

Tabel C3. Certified **constructed wetlands and membrane reactors** and their suppliers

Supplier	System name	Treatment class	Supplier	System	Treatment class
Aqua-Nostra	Aqua-Nostra Pflanzenkläranlage		Busse	Mikrofiltration	
Mall GmbH -	Palutec		Graf	UltraClear	
MUTEC-	System mit integrierter Kompostierung		Huber	MCB	
Oberland Kommunaldienste AG	Sonnenwasser PKA		Klargester	Biodisc	C,N,D
Wasser-Loewe GmbH	Phytofilt - E		Kordes	AQUA-SIMPLEXcrystall	
			Mall GmbH	Ultrasept	
			Wet & Pure	Biorock	