Engineering Kuopio

[LakePromo Summary]

Rural Wastewater Treatment in Finland, the United Kingdom and Hungary

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Foreword

Effective treatment of wastewater is a crusial part of surface and groundwater protection and management. Wastewater may contain large amounts of nutrients, that can accelerate eutrophication of watersheds. Inorganic compounds of nitrogen and phosphorus are the primary reasons for this acceleration, because they are usually the limiting factors in aquatic ecosystems.

In the last decades, many European countries have made major progress in how they treat effluents at the sewage treatment plants. However, especially in rural areas, the wastewaters are treated on-site, in many cases ineffectively. These kinds of diffuse loadings may represent a serious threat to the condition and biodiversity of aquatic environments. In Finland, it has been estimated that in rural areas the discharge of phosphorus to water is 50 % higher than in urban areas. This is the reason why it is crusial that wastewater treatment has to be considered in planning water management and restoration processes.

This manual consists of three country-specific reports, it provides an overview about wastewater treatment in Finland, the United Kingdom and Hungary. The report from Finland has been compiled in cooperation with Savonia University of Applied Sciences, The City of Kuopio and Finnish Environment Institute. The University of Brighton has edited the UK part and the University of Debrecen is responsible for the Hungarian part.

The Finnish portion concentrates on on-site treatment of wastewaters on rural areas, with focus on the solutions designed for small-scale use (population equivalent below 100). In the pilot village of Kaislastenlahti the aim was to involve wastewater treatment as a one of the basic guiding elements in the land use planning.

The UK part describes current practices for both mains connected and non-mains connected households and gives examples of common designs for various process options. Different techniques are described with reference to their suitability to a range of populations and environmental considerations. This part also contains an extended section on investigations on phosphorus stripping using chemical precipitation.

The Hungarian part summarizes the current wastewater treatment methods used in the rural areas and settlements with under 2000 inhabitants. It provides an introduction to the New Hungarian Development Plan and 7 regional operational programmes.

This report was collated as a part of the international EU project called **Lakepromo**, which aims to promote multilevel and interregional co-operation and exchange of experiences in the field of water management. The project concentrates on the planning phase of the water management and restoration processes, the special emphasis is on preventing eutrophication and involving the local inhabitants to participate in these processes.

Lakepromo - Tools for water management and restoration processes, is partly financed by the European Union (Interreg IIIC Programme) and cofinanced by the 12 participating partners from 8 countries (Finland, Estonia, United Kingdom, Denmark, Germany, Spain, Hungary and Russia). Lakepromo-project was implemented over a three year period (September 2004 - December 2007). The knowhow and experiences were exchanged via seminars, meetings and information-packages from each country. Also more practical insight is provided - each partner country has chosen a pilot area (a lake, a wetland area, a coastal area or a larger natural water intergrated area) in which water management processes have been planned. The Lakepromo project group has monitored these projects and has arranged for a sharing of knowledge, for example in workshops.

Savonia University of Applied Sciences (the lead partner and co-ordinator of Lakepromo) wishes to thank all parties and individuals involved in this work.

15th October 2007, Kuopio

Arja Ruokojärvi

Glossary

Black water: Waste water and excreta from water closets excluding waste water from baths, showers, handbasins and sinks

BOD: Mass concentration (mg/l) of dissolved oxygen consumed under specific conditions by the biological oxidation of organic and/or inorganic matter in water.

Buried sand filter: A wastewater sand filter constructed below the surface of the ground and covered with earth to prevent annoyance to nearby dwellings. These filters are often used for disposing of septic tank effluent.

Cesspool: Underground watertight tank without outflow used for collecting domestic wastewater.

Grey water: Waste water from household baths and showers, handbasins and kitchen sinks, but excluding waste water and excreta from water closets.

Leaching field: A system of open pipes in covered trenches that permits effluent from a septic tank to enter surrounding soil.

OWSD: Finland's Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (542/2003).

Package plant: Prefabricated factory-built sewage treatment installation.

Septic tank: Closed sedimentation tank in which settled sludge is in immediate contact with the wastewater flowing through the tank, and the organic solids are partially decomposed by anaerobic bacterial action.

SRP: soluble reactive phosphorus

STW: sewage treatment works

UWWTD: Urban Wastewater Treatment Directive (91/271/EEC)

Reference: Maastik et al (eds.). EnDic2004. Environmental Dictionary. Finnish Environment Institute, Helsinki 2004.

Introduction:
Domestic wastewater treatment in Europe

Over the past decades, remarkable developments have occured in wastewater treatment technologies. The control of point pollution has progressed significantly in most European countries, but pollution from diffuse sources such as wastewater in rural areas is still in need of development.

Domestic households in Europe produce an average of 150 l of wastewater per person every day. It has been estimated that this amount of wastewater contains 50 g organic matter, 2.2 g phosphorus and 14 g nitrogen. Both phosphorus and nitrogen can accelerate eutrophication, cause algal blooms and threaten aquatic biodiversity. Moreover, wastewater can contain harmful micro-organisms and in this way spread diseases.

The Urban Wastewater Treatment Directive (91/271/EEC) is the main regulative document concerned with the treatment of wastewater in the whole EU area. Furthermore, the directive on nitrates from agricultural sources (91/676/EEC) is important in rural areas where sludges have to be separated from wastewater. Country-specific legislation can impose more specific requirements for wastewater treatment as well as standards for planning, construction, use and maintenance of treatment systems.

The proportion of the population connected to wastewater treatment plants has markedly increased since 1980s in all parts of Europe (Figure 1). The highest percentage (80-90 %) is in northern and central Europe and these countries also have the highest levels of tertiary treatment, which efficiently removes nutrients and organic load. It has been estimated that more than 70 % of the wastewater in the Nordic countries undergoes tertiary treatement. In southern and eastern Europe, only around half of the population is currently connected to any wastewater treatment plant and only about 30 - 40 % of wastewater is subjected to secondary or tertiary treatment (Data source: EEA-ETC/WTR based on Member States data reported to OECD/EUROSTAT Joint Questionare 2002).

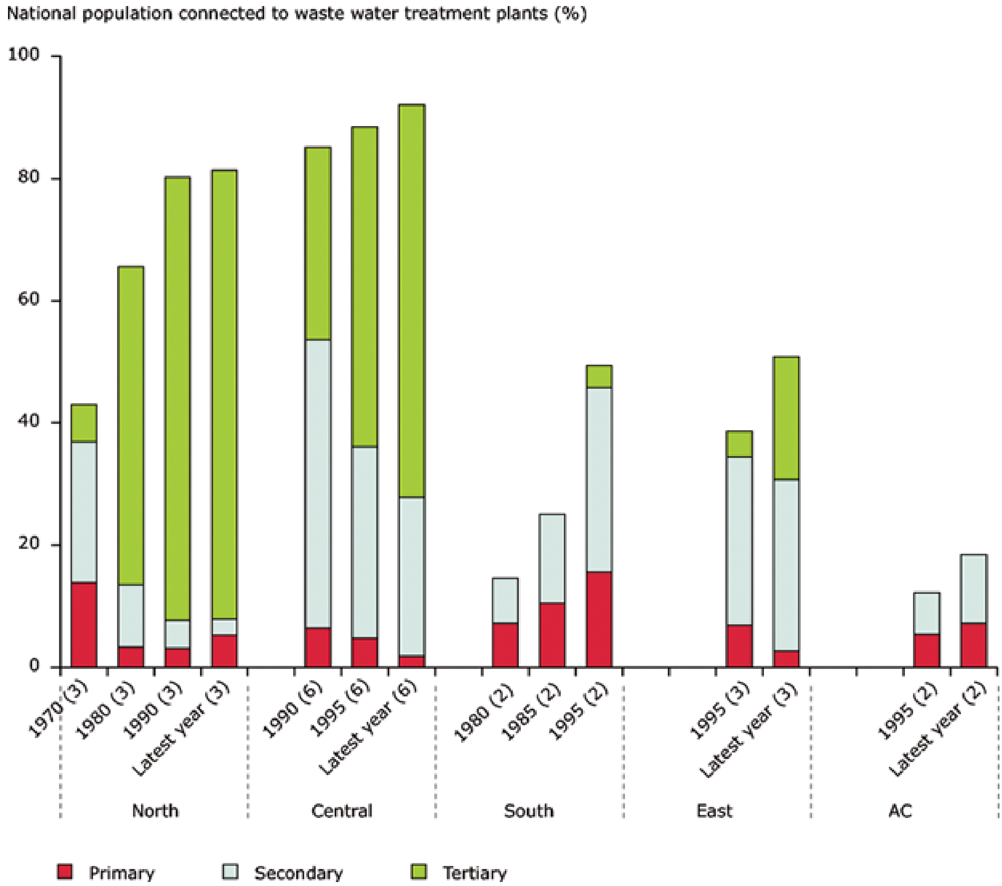
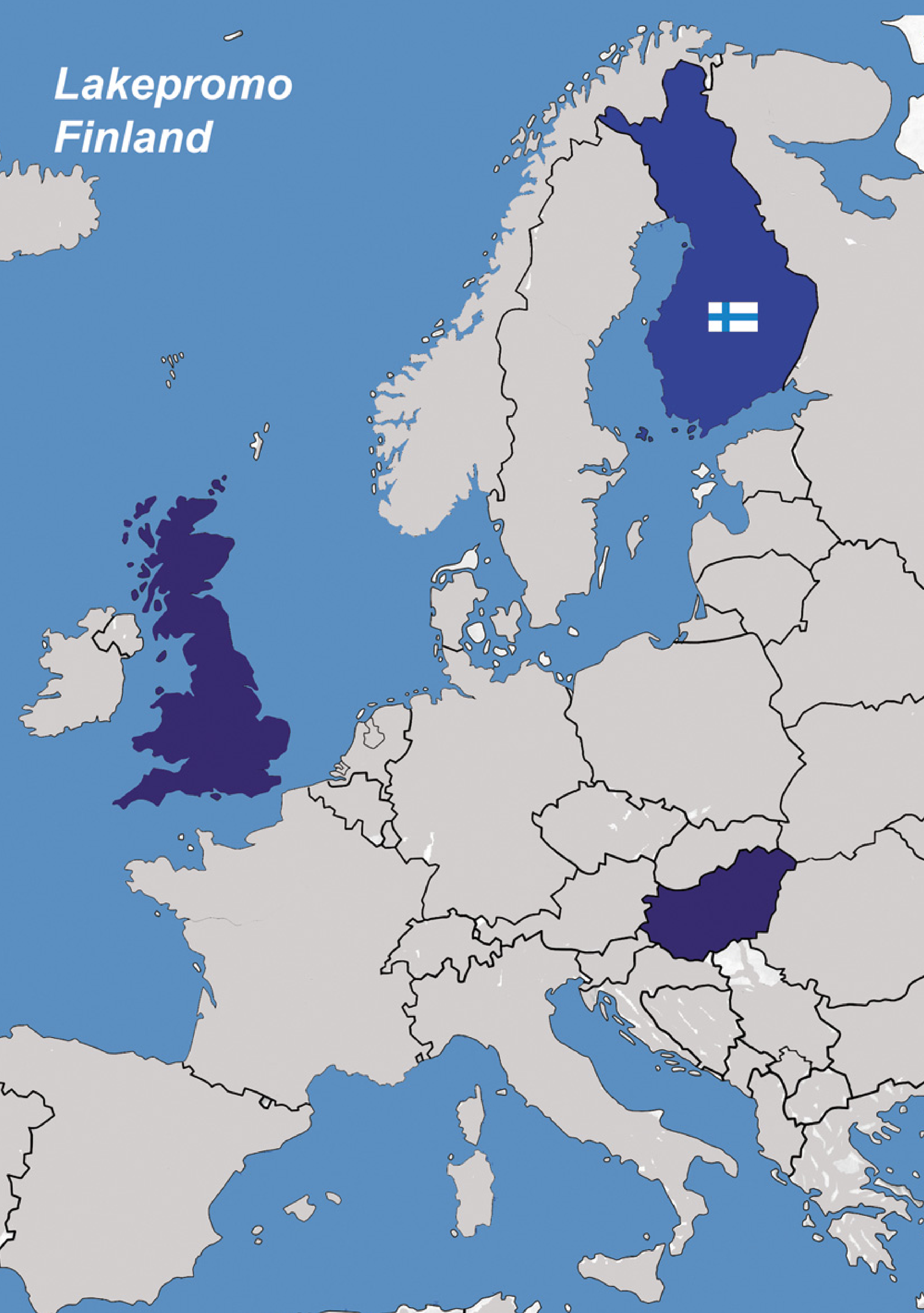


Figure 1. Changes in wastewater treatment in regions of Europe between 1980s and late 1990s (Ver. 1.00). Note: Only countries with data from all periods included, the number of countries in parentheses. Nordic: Norway, Sweden, Finland. Central: Austria, Denmark, England & Wales, Netherlands, Germany, Switzerland. Southern: Greece, Spain. East: Estonia, Hungary and Poland. AC: Bulgaria, and Turkey. Data source: EEA-ETC/WTR based on Member States data reported to OECD/EUROSTAT Joint Questionnaire 2002; EEA: The European Environment - State and outlook 2005; http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=1141, September 2007.

In the following chapters a detailed overview is given in the current state of wastewater treatment in Finland, the UK and Hungary. The focus is on rural areas and small villages. The specific national legislation is reviewed and the most common treatment methods are discussed.


Lakepromo
Finland

Preface

This part gives an overview of rural wastewater treatment in Finland. The first chapter deals with administrative and legislative issues, with a special focus on new demands of the Onsite Wastewater System Decree. This Decree will lead to major improvements in the rural wastewater treatment in the coming years. However, it will also demand much work, investments and co-operation if the very challenging objectives of the decree are to be implemented. One of the most demanding tasks is to advice local people living in sparsely populated areas on how to implement the Decree. There are dozens of onsite wastewater treatment methods and applications currently in Finland, but the problem is to find sufficiently impartial and concise informative material to compare systems in order to identify the best available solution for each individual household.

The second chapter provides an overview of the different wastewater treatment methods that could fulfill the Decree's standards when properly planned, constructed and maintained. The sources of funding are reviewed in the third chapter.

A case study from Kaislastenlahti, Finland, is described in chapter 4. In this area, the special emphasis was placed on collaborative planning in wastewater treatment methods. An overview of this pilot work is given in this information package. Also some other research and educational interests and projects are introduced in the next chapter.

Finally, the last chapter provides a summary of the current state of rural wastewater treatment in Finland and expresses the needs for further development.

Contents

1 Background

In Finland, approximately one million residents and over one million vacationers are located outwith the municipal sewer network. There are about 350 000 on-site wastewater systems serving permanent dwellings (Kaloinen & Santala 2004). It has been estimated that in rural areas the discharge of phosphorus to water is 50 % higher than in urban areas. For this reason, rural wastewater treatment is tightly connected to eutrophication and needs to be considered in planning water management and restoration processes.

The significant portion of the on-site wastewater treatment systems will require improvements during the coming years if they are to meet the demands of the Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (542/2003) and Finland's Environmental Protection Act (86/2000).

1.1 Government Decree on Treating Wastewater in Areas Outside Sewer Networks

The Decree 542/2003, which is also called the Onsite Wastewater System Decree, (OWSD), came into force on 1.1.2004. This Decree sets minimum requirements for wastewater treatment as well as standards for planning, construction, use and maintenance of treatment systems. All the new buildings (built after 1.1.2004) should fulfill the requirements of the Decree immediately; the building supervision and environmental protection authorities will control this at the same time when the building permit is considered (Figure 1). Old wastewater systems have to fulfill the requirements before 1.1.2014. If only very small amounts of wastewater are generated, some exceptions may be granted on a case-by-case basis. If only very small volumes of wastewater are generated, it will be permissible to release 'grey waters' from kitchen and bathroom into the ground in an untreated form. However, this wastewater may not represent any pollution risk or contain toilet water.

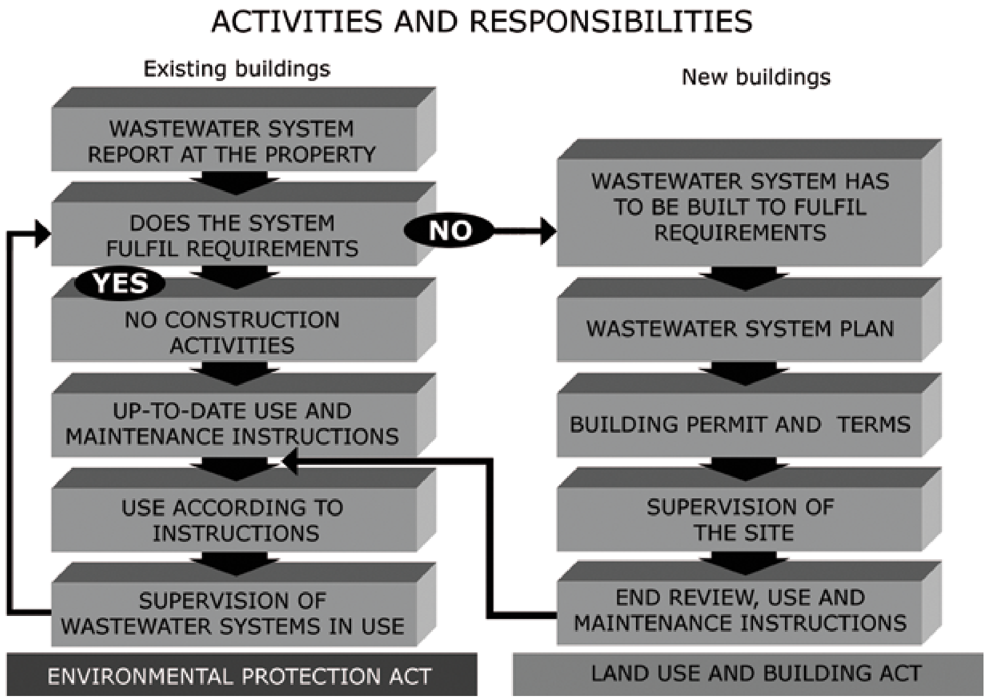


Figure 1. Activities and responsibilities in existing and new buildings (Kaloinen & Santala, 2004).

The OWSD stipulates that at least 90 % of the organic material (BOD7) has to be removed from wastewater, as well as >85 % of total phosphorus and >40 % of total nitrogen, compared with the load in untreated wastewater. The maximum permissible daily loads of the wastewater per capita are defined in the Decree (Table 1). Moreover, the decree lists person-equivalent loads for loading calculations of wastewater systems (Table 2).

Municipalities can appoint slightly higher or lower limits depending on the local conditions; for example higher purification grades are required at special ground water areas. These local standards are defined in municipal environmental protection regulations.

Table 1. The maximum permissible daily load of treated wastewater per capita outside sewer networks (Kaloinen & Santala, 2004).

General treatment requirements of the OWSD The maximum permissible daily load of treated wastewater per capita outside sewer networks			
	Norm load of untreated wastewater (g/person $^{d-1}$)	Required reduction (%)	Permissible load of treated wastewater (g/person $^{d-1}$)
$BOD_7$50	50	90	5,0
P_{tot}	2,2	85	0,33
N_{tot}	14	40	8,4

Table 2. Composition of the person-equivalent load for dispersed settlements; origin of loading and the amounts of different types of loading (Kaloinen & Santala, 2004)

Composition of untreated wastewater according to OWSD Composition of the daily load for untreated wastewater per capita. The values below can be used if other reliable information is not available.			
	The daily load of untreated wastewater per capita (q/person $^{d-1}$)		
load source	BOD_7	P_{tot}	N_{tot}
faeces	15	0,6	1,5
urine	5	1,2	11,5
other	30	0,4	1,0
together	50	2,2	14

The Decree stipulates that all the existing onsite wastewater systems should include a description report and a system report. The owner of the house has to prepare these reports by 1.1.2006 if there is a water toilet in the house. In the case of existing old systems, without WC-wastewater, the reports need to be submitted before 1.1.2008. The use and maintenance instructions must be kept up-to-date at the property and keep a record of any measures done to make the wastewater system more efficient and any other modifications.

1.2 Other related legislation

The Environmental Protection Act (86/2000) defines the general demand to treat wastewaters in a way that will prevent any threats to the environment. If the wastewater treatment plan involves an equivalent number of over 100 persons, then a permit is required (Keski-Suomen ympäristökeskus 2005). Onsite Wastewater System Decree (542/2003; OWSD), which was described in more detail in the previous section, will set more specific environmental requirements for the onsite treatment. Municipal environmental requirements may also result in local more stringent standards (Table 3).

Table 3. The hierarchy of regulations (Kaloinen & Santala, 2004).

The constitution of Finland (731/199)	Everybody is responsible for the environment, authorities shall endeavour to guarantee a healthy environment
Environmental protection act (86/2000)	General demand to treat wastewater and render it harmless
Onsite wastewater system decree (542/2003)	General environmental requirements for wastewater systems
Municipal environmental protection regulations	Local environmental requirements for wastewater systems

The Land Use and Building Act (MRL 132/1999) and Decree (MRA 895/1999) are aimed to ensure that the use of land and water areas and building activities on the land create an ecologically, economically, socially and culturally sustainable development. It is stipulated that the plan of wastewater treatment system should be included in the application for a building permit.

Water Services Act (119/2001) assumes that municipalities take care of overall development and planning in water services. Every household which is in the functional area of the municipal sewage systems or water cooperative society are in principle required to be connected to the system.

2 Wastewater treatment methods

In rural areas traditionally wastewater has been led via two-stage septic tanks to stone drainage or to land treatment sites (conventional leach field). This latter method is still usable, if the toilet waste and washing waters are treated separately (Figure 2). For example if there is a composting closet in use or the toilet waters are led to a cess pool and only the washing waters are being treated by this method. Especially in summer cottages it is very common to use composting toilets.

The investment required to install a single small sewage treatment plant can vary extensively (around 1 000 - 10 000 •). The total costs depend on the location, geographic nature of the site, soil type etc. In many cases it may be possible to utilize existing septic tanks, either in their present condition or after renovation. If the residents are able to do some of the work themselves then this can reduce costs considerably.

Figure 2. A separate dry toilet and washing waters being led to the ground. This solution is possible only if the amount of washing waters is not great. (Tuukkanen 2006)

In the following pages the most common methods and current practices for rural sewage treatment in Finland are described. It is noteworthy that all the methods may not be suitable in every dwelling, each case should be studied and planned case by case.

2.1 Centralized sewer system

Whenever possible it is recommended that the building should be linked up to the sewer network system. The sewer system can be maintained by a municipality or a private water cooperative society. In 2004, there were 560 wastewater treatment plants which were designed for over 50 inhabitants. Wastewater treatment plants have high and controlled purification efficiencies. In the year 2004, the approximate purification rate for phosphorus and organic material was 95 % and 49 % for nitrogen (Santala, E. et al, 2006). Every municipality is expected to have its own development programme for water supply and sewarage, which includes also plans for future network extension.

Restrictions: Long distances to the sewer system or some geographical obstacles may give rise to unreasonably high costs.

Benefits: The maintenance and use is very simple and easy for the houseowner. Very efficient purification rates can be achieved by joint wastewater treatment plants. The costs of network can be divided between many owners and also some financial support can be applied for construction (see the Chapter 3). The centralized method causes no pollution risks for local wells or groundwater.

Costs: On average, the costs for 10 years are 6 000 - 10 000 • (including sewerage costs 40 - 180 •/m, waste water treatment costs 1,5- 2 •/ m3, connecting fee).

2.2 Cluster (decentralized) wastewater treatment systems

The joint sewer system can be arranged for a village or a couple of households (up to 50 people). Many commercial solutions are available.

Restrictions: A joint system requires clear cooperation agreements and division of labour as well as allocation of costs between shareholders. The positions of interested parties, the distances between these sites, the geographical forms and soil types may limit the siting of the system. The establishment expenses may be too high. The maintenance responsibilities should be agreed between estate owners.

Benefits: All the costs (establishment, maintenance and operating expences) will be divided between partners. There are some subsidies available for establishment of a cluster treatment system (Chapter 3). The reliability of the purification rate will be stable since it has several users and more steady wastewater loading. There are many possibilities to choose the best location for the joint system.

2.3 Onsite wastewater treatment systems

If it is not possible or relevant (for example due to high costs) for a building to join a centralized sewer system nor be a part of any other cluster system, then there are a variety of onsite wastewater treatment systems available. The systems can be divided into two groups: methods in which the toilet waste and washing waters are treated separately and methods in which all the waste waters (both toilet and washing waters) are treated in the same way.

2.3.1 Separate treatment systems for toilet waste and washing waters

The largest proportion of total phosphorus, nitrogen and organic load in waste water derives from toilet waste. Therefore it is possible to use more simple treatment techniques if toilet waste (black waters) and washing waters (grey waters) are treated separately. In these cases, a two-stage septic tank may represent a sufficiently efficient pretreatment for washing waters.

A) Dry toilet and separate treatment for washing waters

When only small amounts of water are handled in the location and there is a dry toilet, then it may be possible to transfer the washing waters simply to the ground through a concrete sink ring or stone drainage. This is often the case in many summer cottages or old houses - so-called 'grandma's cottages', which do not have any water pipes or pumps and all the waters used have to be carried into the house.

In better equipped houses (with water pipes) where the use of washing waters is higher, it is required that at least a two-stage septic tank has to be installed as a pretreatment before the efflux enters the leach field (Figure 3) or other treatment system (these systems are described more closely in the next chapters).

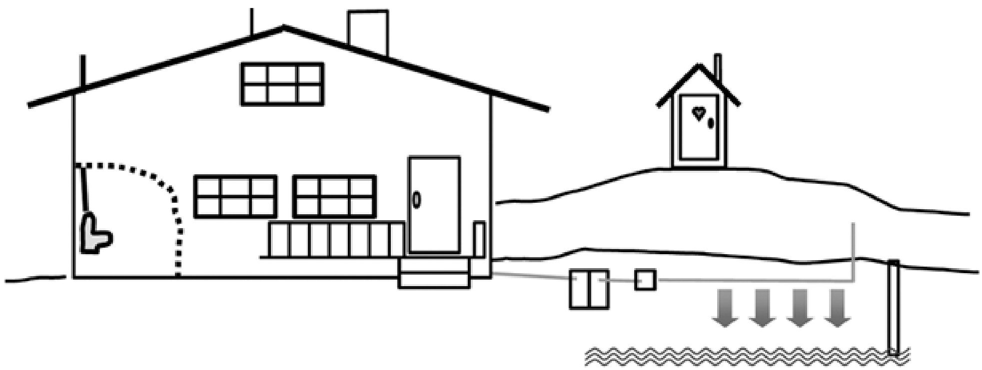


Figure 3. A leach field (Tuukkanen 2006).

A dry toilet can be installed in a separate building outdoors (the usual case in traditional summer cottages) or indoors. Modern dry toilets are comfortable and odorless when properly used, there are many different models and designs available on the market. Most of the models are based on the composting process. It is possible to install a dry toilet also into old buildings.

Composting toilets can be divided into two different types: batch systems and continual process systems. With the batch systems, a container is filled and then replaced with a new, empty container. There are also models that have a carousel system where 3 or 4 containers are mounted on a carousel and a new container is turned in place into the toilet when the previous contained is full.After that, the composting process continues to completion inside the sealed container. Continual process systems are undergoing a constant state of composting. Waste water enters the system, composting reduces the volume and the waste is moved downward where it is harvested after 6-12 months as fully composted material. (http://compostingtoilet.org and http://www.drytoilet.org/).

Restrictions: Special attention in planning should be paid to the emptying process of the composted waste; the tank should be easily reached. The maintenance and operation can be more quite laborous. The selection of the optimal model demands wide and expert knowledge of what systems are available.

Benefits: The maintenance costs are relatively low, emptying can be done without any specific equipment. This method is also usable under the unusual conditions, for example during drought or periods of flooding. The end-product from composting toilets can be used as a valuable soil additive after postcomposting. This process also helps to save pure water; water use reduction is 20 - 50 %. The wastewater will contain less phosphorous and nitrogen, thus it is possible to use simple methods for these waters. There will be no need for separate purification unit for phophorous if there is a sand filter for washing waters. There will be a lesser amount of sludge which in turn will lengthen the emptying intervals and lead to the lower costs.

Costs: On average, the 10 years costs are in the range of 2 000 - 7 000 • (including dry toilet + leach field / buried sand filter or package plant or closed septic tank)

B) Toilet waters transferred to a cess pool and separate treatment of washing waters

This solution differs from the previous one in that it utilizes a flush toilet instead of a dry toilet. Also in this alternative, when toilet waters are led to a cess pool, it is possible to treat washing waters separately with a leach field or sand filter or package plant (Figure 4).

The leach field is suitable treatment for washing waters if the soil is sufficiently permeable, but not too permeable. It exploits the soil's natural purification capacity (natural microbiological processes). Wastewaters are lead through a two- or three-stage septic tank to the leach field.

Figure 4. A solution in which toilet waters are led to a cess pool and washing waters to a sand filter (Tuukkanen 2006).

Restrictions: The cess pool needs to be emptied sufficiently frequently. The emptying as well as transport and treatment of the sludge is expensive. The municipal environmental protection legislation needs to be followed in the sludge treatment. During the planning stage, it is important to pay attention to ensure that the emptying vehicle should be able to easily reach the septic tank, also during wintertime. The leach field is not suitable for compact soil, the leaching qualities of the soil should be carefully clarified in the planning phase. When planning the site of the leach field it is essential to determine that there will not be any risk of polluting groundwater. It is difficult to follow or study the purification rate.

Benefits: When the toilet waters are collected to a cess pool they will not cause any threat to nearby ground and surface waters. Washing waters can be treated by a more straightforward technique (a leach field may be sufficient) than the handling of toilet waters, therefore there is no need for enhanced precipitation of phosphorous when using a sand filter method.

Costs: The average 10 years costs are between 4 500 - 10 000 • (including investment costs for a cess pool + leach field / buried sand filter + emptying, transport and treatment costs of the sludge). In cases where also washing waters are led to the closed septic tank, then costs can amount to over 30 000 •.

2.3.2 Connected treatment systems for all the household wastewater

If all the wastewaters emerging from a household will be treated in a combined manner, then the septic tank for pretreatment should be a three-stage tank. The suitable methods after pretreatment may be leach field (only in restricted cases), buried sand filter (with enhanced phosphorous precipitation) and a small sewage treatment plant. In very vulnerable areas, it may be desirable to gather all the waste water to a cess pool.

Sand filter with enhanced precipitation of phosphorous

This system consists of a septic tank, filter field with collection pipes and phosphorous precipitation, which can be a separate unit, a precipitation layer in the field or chemical addition (Figure 5). The pretreated waste water passes through a bed of sand (around 80 cm thick layer), and the solid particles are filtered out and consumed by bacteria. The sand bed needs to be isolated (by plastic or clay) from the surrounding soil if it is permeable. The distribution pipes are made of perforated plastic pipes (Figure 6). The collection pipes lead the purified waste water to a suitable receiving area. The discharge will be quite clean, only phosphorous may need additional treatment to fulfill the required purification rates.

Figure 5. All wastewaters are treated in a buried sand filter equipped with a separate unit for phosphorus precipitation (Tuukkanen 2006).

In Drän - filtration is based on the same principals as traditional sand filtration. The main difference is that the In Drän -process uses plastic and non-woven modules, which are biologically active. The waste water will become purified when trickling through these modules. This method is usable also in rocky locations, where it is not possible to use traditional sand filters. The first experiences from this method were gained in the Lappajärvi Life -project during 1999 - 2000 (Savola & Rautio 2003).

Figure 6. A buried sand filter. Photo Arja Ruokojärvi.

Restrictions: The buried sand filter needs quite a large field where heavy vehicles are prohibited and it should be left covered by snow during winter. Microbial processes require both oxygen and sufficient loading. There should not be any plants on the filter area that will damage the bed by their roots; a lawn is the safest cover.

Correct usage is essential if this system is to be effective: oils, toxic chemicals, paints or other solvents may damage or kill beneficial microbial flora. There should be enough waste water loading to feed the microbes, but the field should not be too wet (this will lead to anoxic conditions). That is why special attention should be paid to how to handle storm waters (Arosilta 2006).

Special knowledge and planning are needed to ensure proper construction. The grain size distribution in the different layers needs to be known. The filter sand should be changed after about 20 years. Sometimes it may be easier to change the placement of the filter bed, if there is sufficient space. The purification rate of phosphorus will slowly decrease during the years the system is in operation.

The sludge from septic tank should be emptied enough often, otherwise the field can become clogged. The purification of phosphorous may not be sufficiently efficient, it can be enhanced by a separate unit connected to collection pipes. It is also possible to use some additional layer of precipitative material on the filter field or add some chemical directly to the waste waters. However, additional filter material may cause clogging and cementing over time, this may be harmful when it is time to change the material.

Benefits: It is possible to follow the actual purification rate by taking samples from the outlet. It is easy to use and maintain, no electricity is needed. The buried sand filter does not demand any specific soil and is thus suitable for different sites.

Costs: Establishment expenses around 2 500 - 5 000 •, operating costs (emptying and treatment of the sludge) 60 - 200 • per year; the average 10 years costs are between 5 000 to 8 000 •.

Small sewage treatment plants

Nowadays there are many commercial manufactured package-plants available (Figure 7 and 8). They usually contain a pretreatment stage, combined biological and chemical treatment stage and offtake for phosphorous. Usually both electricity and chemicals are required. The different types of package-plants include batch plants, active sludge plants, biorotors and biological-chemical plants. There are models available for single family use but also for use by several households connected to the one system.

Restrictions: The competition between different producers is intense and advertising may complicate the selection process for the consumer. There is only little research available on the long-term function and efficiency of the plants. The development of different models is an on-going process, the systems will probably be refined. The waste water load should be quite stable throughout the year to achieve optimal purification results. The maintenance and service needs to be done by professionals.

Benefits: Package-plants do not require much space and do not demand any specific soil type from the location site. The purification process can be monitored and controlled automatically, alarm systems are connected to the plants. The purification rates are good when construction and maintenance are done carefully.

Costs: Investment costs are around 3 500 - 8 000 •, operating costs vary between 200 - 500 • per year; the average costs calculated for 10 years' use are 5 000 - 10 000 •.

Figure 7. A package plant. Photo Arja Ruokojärvi.

Figure 8. An example of a commercial package-plant as installed. Photo Satu Miettinen.

2.4 Selection of the best available method

The selection of the best available treatment method for wastewater is by no means a simple task. The following list describes some factors that needs to be considered during the selection process:

- limits and regulations given by municipal environmental authorities (municipal environmental protection regulations, municipal development programme for water supply and sewerage), other related legislation, village zoning plans
- location (distances from groundwater level, wells, shorelines, neighbours)
- soil type
- the size of usable area for the treatment system
- how much time and efforts the owner is ready to put in to maintaining and servicing processes
- number of users
- when in use (only summertime and holidays or all year round)
- economic factors (long-time perspective)
- method of water supply, type of closet (separate or joint treatment for toilet and washing waters)

It is recommended that homeowners seek professional consultation and help in planning and construction especially if the owner is not familiar with treatment methods and related legislation. Municipal environmental authorities and regional environment centres can help in obtaining more objective information for different solutions.

2.5 Responsibilities and supervision

The owner of the real estate is in principle always responsible to make sure that house's wastewater treatment will be sufficiently efficient and fulfill the appropriate purification limits.

The application for building permit (since 1.1.2004) must include a wastewater system plan which fulfills the set requirements. Building permits are supervised by local environmental or building authorities. In case of older dwellings, the owner must take care that the old system will be renovated to fulfill the requirements before 1.1.2014.

Use and maintenance instructions for the wastewater system must be kept at the dwelling and the system needs to be used according to these instructions.

Presently there are no uniform or commonly accepted supervisory guidelines or regulations to ensure the verification of sufficient functioning for on-site wastewater treatment plants. During the Hajasampo-project an extensive questionnaire was carried out among municipal authorities, state officials, representatives of environmental protection associationas and construction supervision specialists. The conclusion drawn from these experts' opinions was that from the standpoint of environmental protection, supervision should focus on the most significant locations. Moreover, the requirements established for the design and construction of treatment plants must, for the sake of impartiality, be identical for all sites and be sufficiently stringent (Vilpas et al 2005).

Precise orders and definitions of responsibilities are very important. System producers must conform to the regulations, real estate owners are responsible for the arrangement of water as well as wastewater services, designers and builders are responsible for providing high quality systems and public authorities should supervise overall operations and ensure legal compliance.

3 Sources of funding

There is a need for improvement of 250 000 wastewater systems in Finland with average construction costs of around 3 000 euros / system (varies between 1 400 - 10 000 euros). This means that the implementation of these policies will cost 750 million euros in Finland (Kaloinen & Santala, 2005). Moreover, the operating and monitoring costs will be around 100 - 1000 euros / system / year (Etelämäki, L. & Kujala-Räty, K. 2005). It is estimated that the costs to purify phosphorus from wastewater are around 196 •/ kg-P (Savola & Rautio 2003).

The principal is that the houseowner is responsible for the costs of constructing its own wastewater treatment system which fulfills all the regulations.

Subsidies for improvements of onsite wastewater treatment systems can be applied from governmental funds on social grounds. Homeowners can also claim tax deductions for the work done to improve onsite wastewater treatment systems. Also municipal authorities may allow subsidies to homeowners on social grounds, the maximum support can be up to 35 % of the costs. However the limit of incomes is very low, only 155 households were granted these kinds of subsidies in 2005 in Finland (Pulkkinen 2006).

The Regional Environmental Centres can support investments for centralized sewerage systems. The applicant could be for example water cooperative society, municipality or association. The subsidies should be sought in advance of the actual construction.

The Employment and Economic Development Centres have some subsidies and loans for improvements of wastewater treatment systems, if this is connected to other investments to promote entrepreneurship in rural areas. It is also possible to apply for some EU-funding for joint wastewater treatment systems.

4 Communication and collaborative planning: case Kaislastenlahti

The concept of collaborative planning includes the integration of local inhabitants into the planning procedures from the very onset. Communication and interaction are essential elements influencing the success of the entire project (Lähteenmäki & Rotko 2005). A systematic communication strategy and active dialogue with locals may also help settle disagreements or avoid them altogether (Rotko & Lyytimäki 2004). The planning will proceed more smoothly to the implementation if the objectives and methods are agreed mutually (Hansen 2006).

Genuine collaboration is not easy to achieve. Initially the mutual trust should be built up between stakeholders. All the procedures and decisions should be transparent and all the stakeholders should have equal possibilities to vent their own opinions. Meetings and discussions may also serve educational ends; the environmental responsibility of the local residents may increase during these consultations. On the other hand, local people have very valuable information about local conditions and the history of the area that may be crusial in planning. The next chapter describes an example on collaborative planning project from Kuopio, Kaislastenlahti.

Wastewater treatment and land use planning in the village Kaislastenlahti

The City of Kuopio, Environmental Centre, Technical Services Department / General Planning Office

Photo Kaisa-Mari Immonen

Introduction

In the City of Kuopio OWSD concerns about 80 % of the area. About 9 000 inhabitants (10 % of the city's citizens) are living permanently outside the centralised sewer networks. There are also around 5 000 holiday homes that treat their wastewaters onsite. The municipal environmental protection regulations of Kuopio are at the moment (spring 2007) undergoing the political decision making process. These regulations will set lower purification limits for most of the rural area of the city.

Background information of the village Kaislastenlahti

The City of Kuopio consists of a rather small urban centre and a wide rural area. Land use in most of the rural area is regulated by master plans. In the rural part of the city there are about 20 small villages with their own schools, shops and other services. The city is making more detailed land use plans for these villages, so called village plans.

The pilot area Kaislastenlahti is a small village with about 260 inhabitants. It is situated at a distance of 18-20 km from the city centre. At the moment there are about 100 permanent residences and 25 holiday homes. The number of permanent houses is increasing by 4-5 per year. The school of Kaislastenlahti has about 40 pupils. In the school there is also a day-care unit catering for 10 children.

The master plan for this area was created in the beginning of the 1990's. In this plan, the open field areas in the centre of the village have been reserved for agricultural use without new construction. New building sites should be located in the forested areas near the village centre and in the forested edges of the fields. In the master plan there are also two areas reserved for water fowl nesting which should be protected according to the nature conservation act.

The water supply of the village is organized by a private co-operative. The sewer network runs at a distance of 10 km from the village centre.

Objectives of the project

Village Kaislastenlahti was chosen as a pilot area of the Lakepromo-project in order to combine the needs of rural wastewater treatment to traditional land use planning. The aims of the project were to integrate wastewater treatment as one of the basic elements guiding land use planning, to promote cooperation between different stakeholders and to increase participation of local land owners and inhabitants. The results of this project are going to be used in village planning in other parts of the city.

Co-operation with local inhabitants

The planning process started in 2005 by preparation of a questionnaire which was sent to all landowners with building sites over 0.5 hectares. The questionnaire was sent again in the summer of 2006. The questions asked concerned the present use of the farm or site, area of cultivated or uncultivated fields, plans for the imminent use of the site and desires of land owners for new building sites etc. The existing water supply and wastewater treatment systems were also inquired.

Five meetings with the local inhabitants have so far been organised during the different stages of the planning process (Figure 9). In addition, the inhabitants have chosen four representatives and these individuals have participated in more aspects of the planning process in a smaller group. The survey of the existing wastewater management systems was also made in close co-operation with the inhabitants.

Figure 9. The project was presented to inhabitants in the local school. Photo: Eila Kaartinen.

Survey of existing wastewater systems

In the summer of 2006 the Environmental Centre of the city gathered information on all the existing wastewater treatment systems operating in the planning area. In order to facilitate the work and promote participation, the area was divided into smaller groups of about ten households. Each sub-area had a contact person selected by the inhabitants. The contact person collected information and helped in contacts during the work. Two officials of the Environmental Centre visited all of the households together with the contact person. Almost all of the house owners had already filled in the wastewater system reports required by the Onsite Wastewater System Decree. In addition to the collection of information needed for the village plan, personal guidance on wastewater treatment was given to the home owners. Some informative material was also disseminated.

Land use planning

In the summer of 2006 the Technical Services Department of the city carried out a landscape, architectural and environmental analysis needed for the village plan (Figure 10). Available new building sites had been identified on the basis of the initial analyses and the desires of the landowners.

The land use plan has been made in close cooperation with the local inhabitants. New building sites were chosen in conjunction with land owners. The village landscape was very important aspect when the location of new houses was decided. Common principles of improving the village landscape were also considered important.

New ways of developing housing suitable for an "urban country side" were considered together with the inhabitants. Several important aspects to be taken into consideration were mentioned e.g. space and the proximity of nature, possibility for different generations to live together, working at home and all kinds of hobbies connected with the countryside. Constructions suitable for urban neighbourhoods were reviewed and new solutions based on traditional agrarian style were emphazised. Variation in the size of building sites was desired because of the different needs of the inhabitants.

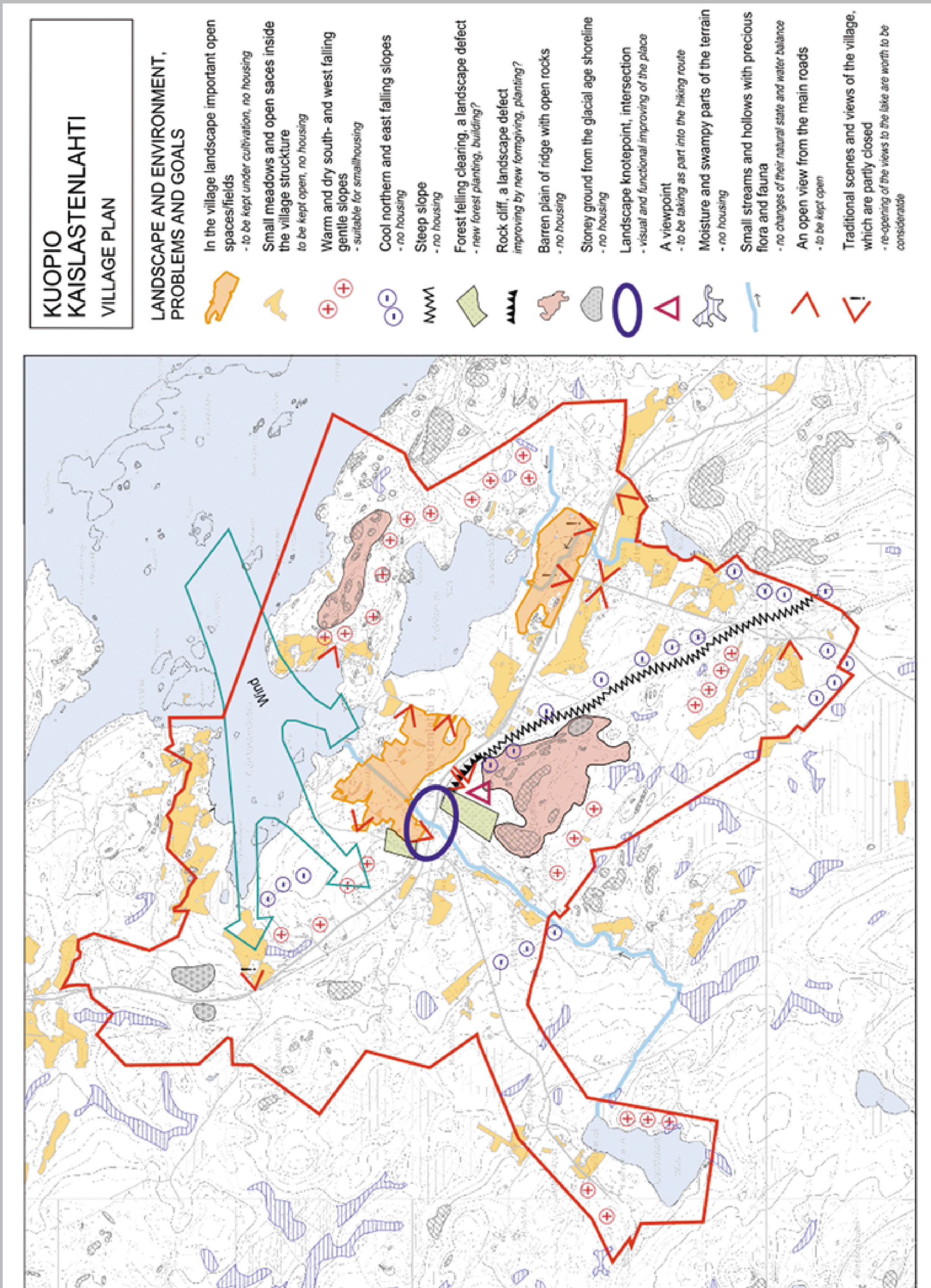


Figure 10. Village plan (Kuopio Kaislastenlahti).

RESULTS:

Existing wastewater systems

The wastewater treatment systems were checked in 126 properties, 102 of which were permanent residences and 24 holiday homes. The collected data revealed that only one quarter of the systems fulfil the requirements set by the Onsite Wastewater System Decree. Some renovations would have to be made in 20 % and a totally new system would be needed in one half of the houses (Figures 11 and 12).

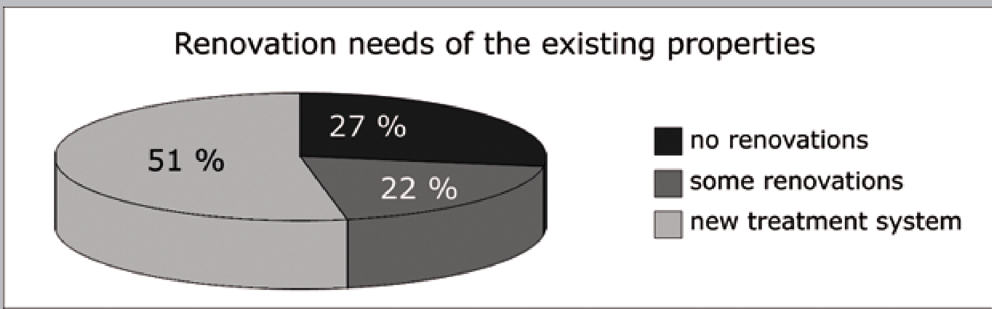


Figure 11. Renovation needs of the wastewater treatment systems of existing properties.

Figure 12. Two septic tanks and a leach field in a small building site which will have to be replaced by a new treatment system. Photo Eila Kaartinen.

Land use plan

The land use plan makes it possible to create about 100 new building sites which will double the number of houses in the village. With a building rate of 3-5 new dwellings per year the plan will be the basis for building in this village for some decades. New building sites have been located in groups of 4-8 houses. The size of the sites varies from 3 500 m^2 to over two hectares. The smallest building sites are in the centre of the village and the largest sites on its outskirts. In a building site of 5 000 m^2 or more, all the wastewaters can be treated in the site. The land use plan is based on the basic services already existing in the village.

Wastewater treatment of the new building sites

Wastewaters of the new building sites can be treated in many ways either separately in each property or in clusters of different number of houses. One possibility for the future is to link the households to the sewer network.

In the land use plan of Kaislastenlahti, the emphasis has been put on joint sewer systems of clusters of houses. The suggested clusters can be found in figure 13. and in table 4. Recommendations have been made for 26 clusters including about 100 new and about 20 existing properties.

Joint treatment systems can be used, if the buildings are located in groups close to each other. Old properties which need to renovate their wastewater treatment can also be connected to these joint systems. In joint treatment systems, all the costs (establishment, maintenance and operation expenses) can be divided between the partners. There are also some subsidies available for cluster treatment systems. The reliability of purification rate will be stable since there are several users and there will be less fluctuations in wastewater loading. There are also more possibilities to choose the most suitable location for the joint system which is a benefit especially for small building sites.

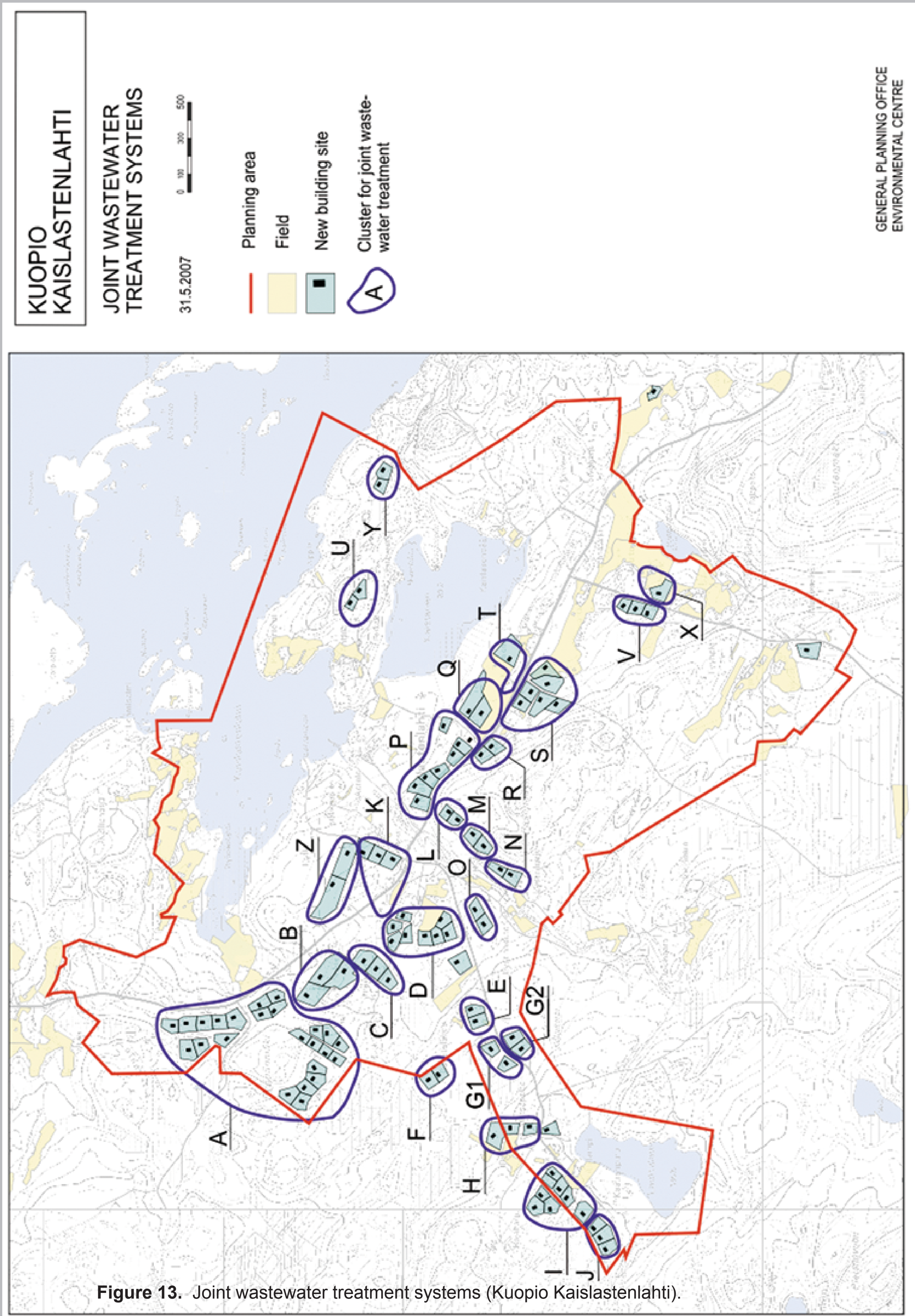


Figure 13. Joint wastewater treatment systems (Kuopio Kaislastenlahti).

table 4

table 4

table 4

The greatest restriction for the use of joint systems is that construction of building sites does not happen at the same time. Because of this kind of phased construction, it is difficult to define the division of costs between different property owners. Clear and explicit agreements about cooperation, division of labour and costs are needed. Agreements about maintenance of the joint systems are also important. The best solutions would be if the property owner could install the joint treatment systems even before selling new building sites.

There are different kinds of systems available, some are suitable for an individual building site as well as for a cluster of sites. Many commercial solutions are also available. The systems recommended for the different sites can be found in figure 13 and table 4.

Commercially manufactured package-plants can be used both for either single house and for a joint system of several households. Package plants do not require much space or a specific type of soil. They can also be brought into use in phases. In the planning area, there is one example of a cluster of many houses (cluster A) and many examples of clusters with 2-9 properties.

Buried sand filter is suitable for both individual building site and for a cluster of houses. It can also be brought into use in phases according to the phase of construction. Buried sand filter does not require any specific soil and is thus suitable for different sites. It needs, however, a quite large field which should be covered by snow during winter time. Use of heavy vehicles is not allowed on the filter field. A buried sand filter could be used in most of the properties in Kaislastenlahti. According to the municipal environmental protection regulations no enhanced phosphorous precipitation is needed outside shoreline areas and in building sites over 5 000 m^2.

The municipal environmental regulations also make it possible in this area that leach fields can be used for individual properties. Leach fields are not allowed in shoreline areas and in building sites under 5 000 m^2. The soil quality has to be suitable for leaching. In the planning area, there are new building sites located in areas with clay, silt or rock where leach fields cannot be used.

Dry toilets can be used in all properties. Currently, there are many different models and designs on the market (Figure 14). When a dry toilet is being used, a separate system is needed for washing waters. The so called grey waters can be treated in a joint system, e.g. a buried sand filter or a small treatment plant.

Figure 14. Dry toilets can be used in all properties. Photo Tuula-Anneli Kinnunen.

DISCUSSION:

Wastewater treatment

In the village of Kaislastenlahti, at present only one quarter of the wastewater treatment systems fulfil the requirements of the onsite wastewater treatment decree. This means that many renovations will have to be done before 1.1.2014 when all the systems have to be in good condition. The situation is obviously the same in other rural areas of Kuopio.

At the moment there are several methods suitable for wastewater treatment in areas outside the sewer network. Some of these are commercial solutions. Some limitations may place restrictions on which methods can be used (e.g. leach field by soil quality or by the size of building site). In the land use plan of Kaislastenlahti, the emphasis has been put on joint wastewater treatment systems of clusters of houses. Also these clusters have several possibilities for wastewater treatment. The actual realization of many of the suggested systems is, however, rather unlikely because the construction of the neighbouring building sites very rarely happens at the same time. Joint systems require also agreements about costs and division of labour, a model which does not fit very well into the Finnish way of life or schedule of building houses in rural areas.

Wastewater treatment in rural areas has so far been considered in one property at a time. In this project wastewater treatment and its connections to other land use have been reviewed at the village level. The developed method will be used in other planning processes of the same type of settlements. This project made it clear how important it was that there should be an overall wastewater treatment plan also at the city level.

Land use plan

Living in a village near to the city is a good alternative to living in urban one-family houses. On the other hand, adherence to the village plan ensures that new building will happen in a planned way. Construction will also take the natural landscape and the characteristics of the village into consideration so that the traditional rural landscape remains intact.

Realization of the plan depends mainly on the activity of the land owners. An approved village plan, however, makes it easier to designate building permits in the area.

The inhabitants of the village have participated very vigourously in the planning process. The dialogue with the local inhabitants has brought forth a common vision of the future of the village and a strong commitment to the plan.

Objectives of the project

Most of the objectives set for the Kaislastenlahti case have been realized. The participation of the local inhabitants and land owners has probably been the best aspect of the project. The local contact persons played a key role in implementing the survey of existing wastewater treatment systems. Each contact person knew his or her own sub-area and helped in contacts with property owners during the work. The model created is feasible for using in surveys of other areas. Representatives of the villagers have also participated in a smaller working group which has dealt with the land use plan.

A great deal of information on wastewater treatment and new solutions has been collected. This data will be used not only in the village of Kaislastenlahti but can be valuable in other rural areas of Kuopio. During the project also much information on wastewater treatment has been given to the inhabitants. The house owners have received an evaluation of their existing systems and definitions of needed renovations.
The cooperation between different stakeholders did not increase as much as was hoped. The old traditions of working were used especially in land use planning. Wastewater treatment was not considered as one of the basic elements determining land use planning, but instead it was assessed afterwards when the building sites had already been identified. According to these results, much closer teamwork between different experts is needed in developing projects like this. The teamwork should start from the very beginning and continue to the end of the project. For the process there should also be a more exact working plan and schedule to which all participants should be committed.

5 Research and education

Recently, a couple of comprehensive studieshave been published on the functionality of on-site systems. The 'On-site Wastewater Treatment Plants Functionality Study, Hajasampo Project' was carried out between 1998 - 2000 by the Finnish Environment Institute (Kujala-Räty & Santala 2001). In the Lappajärvi Life - project different treatment methods were also studied, for example the use of the In Drän -filtration technique (Savola & Rautio 2003).

One extensive research was 'Ravinnesampo Project: Enhancing nutrient removal efficiency of onsite wastewater treatment systems', which consisted of two parts: Part 1 - Treatment of domestic wastewater and Part 2 - Wastewater treatment on dairy farms (Vilpas, R. et al 2005). The project aimed to find out which systems conform to the requirements laid down in OWSD. The main goal of the project was to improve the nutrient removal efficiency and to promote further product development especially of those systems which were already found to perform well. Almost all the investigated systems removed organic matter and nitrogen to the required level, but only half of the systems also achieved adequate phosphorus removal to meet the requirements.

The results of above mentioned studies have been used as guidance when the recommendations about suitable methods have been evaluated.

The project '*Ylläpitosampo - Management and maintenance of onsite waste water treatment systems*' searched for the best models for management and maintenance of the water supply equipments and constructions in rural areas. In practice, the maintenance work includes adjusting the biological, chemical and physical processes and troubleshooting. In the pilot areas a model was developed for organizing the local maintenance cooperatively. The interview study revealed that the interviewees were not familiar with their waste water treatment equipment and construction. Wastewater treatment does not interest the general public if it seems to be functioning properly. (Etelämäki, L. & Kujala-Räty, K., 2005).

In 2006, the Finnish Environment Institute initiated a performance testing for the small wastewater treatment plants according to EN-standard 12566-3. This testing is one of the preconditions for CE-marking on these plants.

After the launching of the OWSD several guidelines and manuals have been published aimed at different user-groups (planners, administrators, consultants, students, houseowners etc.). (Kröger 2005, Keski-Suomen ympäristökeskus 2005).

Some comprehensive sites for wastewater practices are available on the internet: (Suomen vesiensuojeluyhdistysten liitto) www.jatevesi.fi and http://www.ymparisto.fi/.

Special education for planning and constructing treatment systems is given locally in several places, for example in Hämeenlinna, Helsinki and Kuopio. Many seminars and informative events for a wider audience have been arranged all over the country. Also many local surveys and projects dealing with wastewater treatment procedures on rural areas have been implemented (Teiska & Heiskanen 2003). Some enterprises have conducted more specific research and development projects on their own systems.

6 Summary and needs for development

All the onsite wastewater systems that have been constructed after 1.1.2004 should meet the requirements of the Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (OWSD). In case of older dwellings, most systems will need at least some renovation to be done.

Local inhabitants are aware that the new Decree means some new constructions, but there is still a lot of uncertainty about which are the suitable methods and when is the right time to act. Professional consultation and planning is needed in most cases. Many people are still waiting for the development of the systems and for lower prices. This may cause backlog of orders near the year 2014, when all the systems will be required to meet the requirements of the OWSD.

Residents living in sparsely populated areas wish to receive more financial aid and informative support in planning and constructing their wastewater treatment systems. According to a survey done in 1999-2001, individuals are willing to pay around 35 euros per year for the maintenance of the treatment system and furthermore, they were ready to pay around 110 euros for the planning of the system. (Nelimarkka & Rautio 2001).

Proper planning has an important role to make sure that the system will work efficiently in the selected location and with different loads. Special attention should be paid also to careful implementation of each step in the construction phase: that the right type of gravel is used in the filter bed, storm waters are prevented from entering the system, the system is protected against frost etc.

It is importants in onsite wastewater treatment that careful attention should be paid to preparing for hazardous events. This is especially important if the water supply is also located onsite. Drought, flood, electricity failure, frost, insufficient maintenance and groundwater contamination are examples of the hazards that may threathen the onsite water supply and sanitation processes (Arosilta 2006). However, many risks can be prevented and controlled by proper maintenance of the systems. This may not require any massive investments; the effective operations can be as simple as emptying the sludge sufficiently frequently, checking the function of the system regularly, using only environmentally degradable detergents etc.

Cluster wastewater treatment systems would represet an effective and economic solution in several cases. The difficulty in initiating cooperation and fear of losing independence are the main obstacles in planning the joint systems. This could be overcome by providing the inhabitants with proper information on the financial and environmental benefits.

The suspicions that there might be odour emissions and difficult in emptying the system are the most common reasons why people only very rarely choose a dry toilet and composting. However, modern composting toilets are very convenient to use and offer a very economic and efficient technique, usage is independent (no electricity or water pipes are needed). Appropriate education may help in increase the popularity of composting toilets in household use.

In general, people find the maintenance and usage of onsite wastewater treatment systems to be difficult and expensive. The producers of package-plants and other systems need to further develop their systems to make them more simple to maintain and to include sufficiently clear instructions for usage. More needs to be known about the long term effects of package-plants and other novel applications. The utilization of sewage sludge is also an area needing more research and development.

One of the challenges in the near future will be how to arrange the adequate supervision of the systems and their maintenance. Different monitoring practices in different municipalities complicate this situation, precise definitions of the responsibilities are needed. Overall the information on the different possibilities of wastewater treatment and service contracts needs to be unified and simplified. Today it is still rather difficult to select the best available method when different enterprises advertise a vast variety of products.

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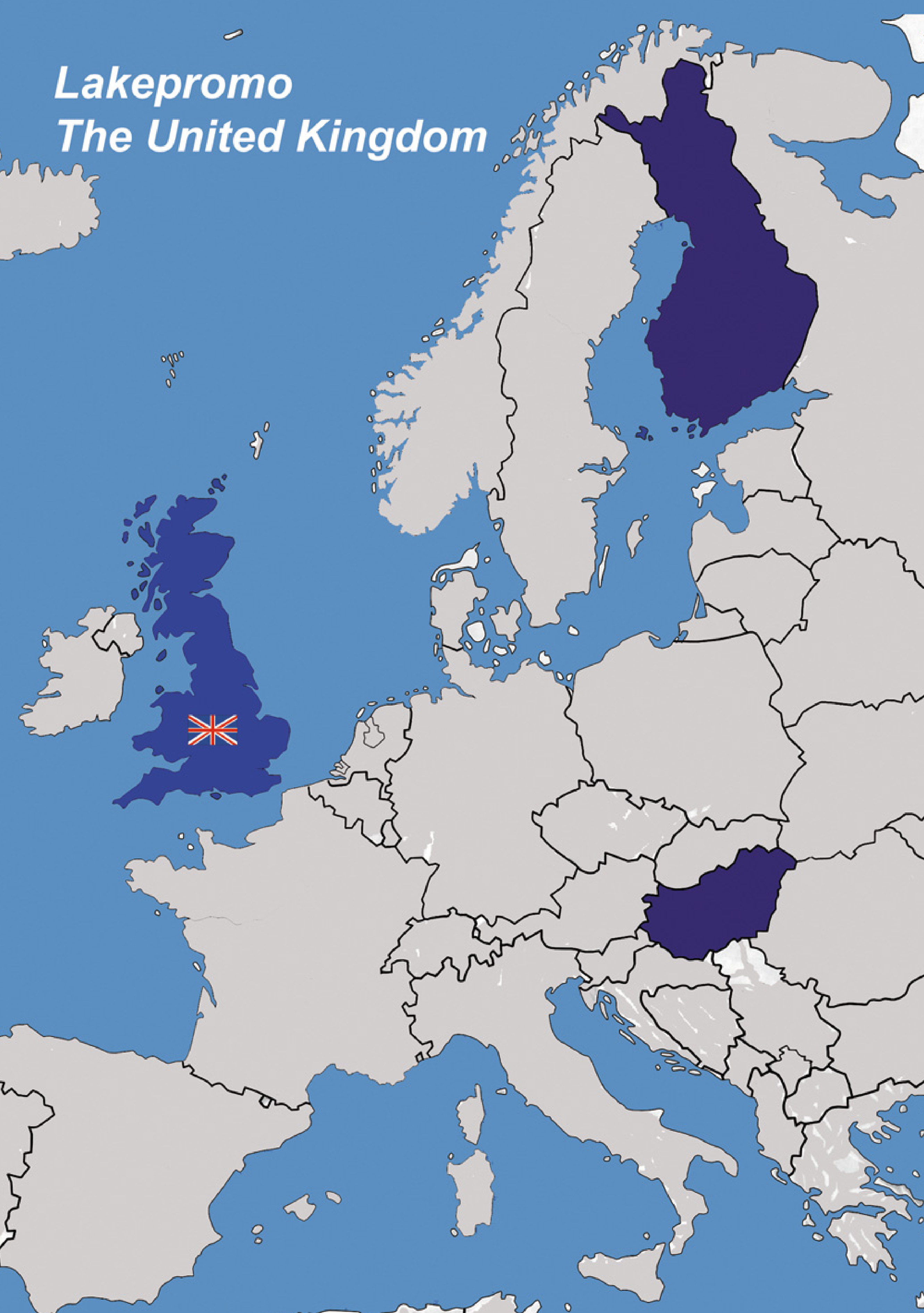

Lakepromo
The United Kingdom

Rural wastewater treatment and nutrient stripping in the United Kingdom

Report prepared by the University of Brighton for Lakepromo rural sewage treatment sub-project
May, 2007

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Executive summary

Rural areas often provide valuable habitats for a diverse range of floral and faunal communities. In order to sustain high levels of biodiversity in rural areas, it is important that effluent discharges from sewage treatment works (STW) are managed in a sustainable and environmentally sensitive manner, exerting no negative ecological impacts within the receiving drainage systems.

This report presents the findings from a study carried out by the University of Brighton investigating the prevailing methods of rural sewage treatment, and extent of their usage in the UK. Both a brief introduction to UK water industry organisation and history of UK sewage treatment are given, providing background information to the reader. Methods of sewage treatment for both mains connected and non-mains connected households are presented and common designs are given. Techniques are discussed with reference to their suitability to a range of populations and environmental consideration. A case study of effluent treatment reed beds is also provided.

Administrative and Legislative structures giving details of all major UK laws governing rural wastewater treatment are presented, with particular reference to the European Union Urban Waste Water Treatment Directive (91/271/EEC) and its UK implementation. Examples of suitable project management plans and process option selection procedures are also presented.

This report contains an extended section on UK tertiary treatment, primarily investigating phosphorus stripping using chemical precipitation. This section gives the results of an investigation by the University of Brighton into the extent and predominant methods of nutrient removal currently used at UK STW and the drivers behind installation of schemes.

This report was prepared by the University of Brighton for the Interreg IIIC funded Lakepromo research project.

Contents

1.0 Background

Effective regulation and management of effluent from sewage treatment works (STW) is fundamental in protecting the ecological and chemical water quality of downstream aquatic ecosystems. STW effluents may contain large nutrient loads [primarily inorganic compounds of nitrogen (N) and phosphorus (P)], that may promote excessive aquatic plant growth, reduction of dissolved oxygen levels during periods of biotic respiration, and increase of cyanobacterial, phytoplankton and epiphytic/benthic algal populations (Chapman, 1996) all of which have the potential to severely disrupt riverine ecosystems functioning. Within freshwater systems P, in particular soluble reactive phosphorus[1] (SRP), tends to be the limiting nutrient (i.e. in the shortest supply) thus is the more important nutrient regarding riverine eutrophication.

Phosphorus concentrations can be delineated into trophic states and a commonly used trophic status classification was produced by the Organisation for Economic Co-operation and Development (OECD), this is shown in table 1.1. Generally, the higher the trophic status, the lower the chemical and ecological water quality is likely to be (Chapman, 1991).

Table 1.1. OECD trophic status classifications (OECD, 1982)

Decreasing water quality

Trophic Status	SRP (μg-P l^{-1})
Ultra oligotrophic	<4
Oligotrophic	<10
Mesotrophic	10-35
Eutrophic	35-100
Hyper-eutrophic	>100

Increasing trophic status

Due to the variety of hydrological catchments in England and Wales, there is no accepted standard for P in freshwater rivers, however a concentration of 100 μg-P l^{-1} has been proposed by the Environment Agency (EA, 2000). Anthropogenic P loads to rivers are primarily derived from two sources:

i) diffuse (i.e. scattered, or discrete, discharges that may be collectively significant delivered overland to waterbodies from a range of sources, notably agricultural);

1 (SRP; soluble = can be filtered through 0.45µm filter; reactive = reacts with molybdate to form phosphomolybdenum blue or 12-phosphomolybdate)

ii) point (i.e. continuous, or intermittent, discharge delivered to watercourse through a defined outlet point, notably STW).

Total P load to UK rivers has been estimated as 50% diffuse, 50% point in origin (Defra, 2006), but it is thought that point sources pose the greatest risk to riverine trophic status (Jarvie et al, 2005). During periods of ecological sensitivity, i.e. spring/summer low flows, point sources tend to dominate P budgets due to decreased in-stream volumetric dilution and limited overland transportation of diffuse sources (Jarvie et al., 2005). Moreover, point sources, notably STW effluent, tend to contain higher fractions of SRP than diffuse sources, which are likely to be dominated by particulate phosphorus (PP; Jarvie et al., 2005). SRP is more immediately bioavailable than PP (Ellison and Brett, 2006) thus is readily assimilated by phytoplankton, bacteria and higher plants; some fractions of PP are immediately bioavailable, but these are limited. SRP loads in STW final effluent are mainly derived from human excreta and household detergents (Rybicki, 1997), and typical P compositions of STW final effluent is shown in table 1.2 (pp.2) Sodium tripolyphosphate (STTP) is the main P containing constituent of commercial washing powders and transforms into orthophosphate when in a waterbody (Estela and Cerda, 2005). Recognising this, numerous EU Member States have banned STTP use (zeolite being a common replacement) and typical P concentrations in domestic wastewaters are likely to have fallen (Rybicki, 1997) in these areas.

Table 1.2. Phosphorus compound structure in European domestic wastewater (Adapted from Rybicki, 1997)

P compound group	1971 (μg-P l^{-1})	1991 (μg-P l^{-1})
Orthophosphates (SRP)	5000	3000-4000
Tripolyphosphates	3000	2000-3000 (tripoly- and pyro- together)
Pyrophosphates	1000	
Organic phosphates	<1000	1000
Total phosphorus	<10,000	<7000

Nationally, the UK government is addressing the problem of anthropogenic nutrient delivery in two ways:

i) Adoption of the Urban Wastewater Treatment Directive (91/271/EEC; UWWTD)

The UWWTD requires the introduction of secondary biological treatment at STW >10,000 population equivalent (p.e.) and also the introduction of tertiary nutrient removal (nutrient stripping) at STW >10,000 p.e. discharging into designated Sensitive Areas (SA). Tertiary nutrient removal aims to reduce P concentrations in STW effluents to 1000-2000 μg-P l^{-1} and is the primary method of reducing highly bioavailable SRP concentrations employed in the UK. Although £250 million was allocated to the installation of such schemes during asset management planning stage 3 (AMP3), which ran from 2000-2005 (Water UK website, 2007), the number of UK STW with tertiary P removal is significantly lower than many other European Union member states (Anon, 2004) possibly a result of UK water industry structure (see sub-section 1.0.1 and table 5.2);

ii) Introduction of agri-environmental farming schemes.

Agri-environmental schemes encourage environmentally sensitive farming practices such as reducing amount of pesticides and herbicides used, whilst promoting wildlife sensitive land management. As diffuse agricultural P sources are thought to be of lesser importance to riverine eutrophication (Jarvie et al., 2005), these schemes will not be discussed in detail in this report.

The introduction of the Water Framework Directive (WFD: 2000/60/EC) adopted in October 2000 incorporates many existing directives, streamlining legislation and increasing management efficiency. Prescriptions outlined in the UWWTD are still applicable to UK waterbodies, whilst new objectives have been incorporated.

The concept of rural wastewater treatment within the UK is vastly different from other EU member states. As approximately 98% of UK households are connected to the mains sewerage network (Dee and Sivil, 2001), the majority of municipal waste (both urban and rural) is transported through mains sewers to STW where it undergoes conventional treatment (see sub-section 1.2). Non-mains connected households have a range of sewage processing options and these are discussed in sub-section 1.1. An important underlying foundation behind any examination of the UK wastewater industry is the concept of privatisation; this is discussed in the following sub-section.

1.0.1 The UK water industry

Unlike most other EU Member States, both the UK's water supply and wastewater industries are privately owned, thus both profit and environmental concerns are the motivating factors behind process improvements (Ogden and Anderson, 1999). Prior to industry privatisation, the infrastructure was fragmented, consisting of approximately 29 River Authorities, 198 water supply companies and 1,393 sewage disposal authorities. It was the adoption of the 1973 Water Act that facilitated the creation of 10 Water Authorities serving England and Wales (see appendix I), supplying both potable water and providing sewage treatment and disposal. The formulation of 10 regional water authorities allowed for an increasingly holistic approach to water resource management focusing on whole river basin catchments, rather than discrete waterbodies in isolation. During the 1980's it was recognised that widespread capital investment was required to meet both increasing public consumption and standards imposed by the transposition of new EC Directives. Privatisation in 1989 facilitated this infrastructural development and generated the required cash in three ways (Twort et al., 2000):

i) Being removed from government financial regulations, the newly created private companies were granted increased borrowing powers free from Treasury constraints;

ii) New companies were floated on the stock market, upon which previous accrued debts were written off, making shares more attractive;

iii) The companies were allowed to increase water and waste processing prices (subject to regulation by (OFWAT; see sub-section 2.1).

Post privatisation, water and sewerage companies shifted their focus from cost limitation to profit production (Ogden and Anderson, 1999) representing a monumental shift in policy, attitudes and economics. The end user was now a customer to which products could be sold rather than a rate-paying member of the public to be served. Many commentators considered privatisation as a mistake, predicating widespread price rises and decreases in customer service. Indeed, both water and sewerage prices have risen steadily post-privatisation (table 1.3) and are projected to continue doing so (Ofwat 2005a).

Table 1.3. Price changes in the post-privatisation period (Ofwat, 2005a)

Component	% 1989-2006 Increase (excluding inflation)
Water	45.9
Sewerage	36.7
Combined services	41

A litre of tap water currently costs approximately 0.18p (including costs associated with sewage treatment) whilst the average daily household bill for both drinking water and sewage services is 76p/per day (Ofwat, 2006). Capital investments and infrastructural spending has also increased significantly post-privatisation (table 1.4), perhaps vindicating some of the drivers originally given. Of the total amount spent between 1990 and 2000, approximately £9.2bn was invested developing sewerage infrastructure, and it is estimated that a total of £5.3b was spent in the period 2000-2005 (Defra, 2006).

Table 1.4. Average annual capital investment, 2002-2003 prices (Ofwat, 2005b)

	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010
Water and Sewage companies	£1.5bn	£1.9bn	£3.3bn	£3.5bn	£3.1bn	£3.2bn
Water only	n/a	n/a	£0.2bn	£0.3bn	£0.2bn	£0.2bn
Total	£1.5bn	£1.9bn	£3.5bn	£3.8bn	£3.3bn	£3.4bn

1.1 Current practices and methods available for the treatment of non-mains connected households in the UK

Approximately 98% of UK households are connected to the mains sewerage network, owned and operated by 10 private regional water and sewerage companies (Dee and Sivil, 2001). Sewage from these households is transported via the mains sewer system to STW where it is processed in accordance with discharge consents set by the environmental regulator (see sub-section 2.1). The distribution of the unconnected 2% of households is currently unknown, but it is probable that due to lower population densities and historic lack of sewage infrastructure many of these properties will be situated in rural areas. It is for this reason that the following sub-section discusses process options for households currently unconnected to the mains network rather than specific rural areas.

Note: In the following sub-sections suggested designs and dimensions are given for various process options. These come from BSI British Standards, a testing organisation with a Royal Charter acting as the UK standards organisation for a wide range of products. Manufactured products that state confirmation to a BSI British Standard are assumed to be safe and compliant with all relevant UK and EU laws and directives.

1.1.1 Cesspools

Cesspools are the most basic form of sewage treatment, typically comprising an underground watertight tank receiving domestic waste from a single or a small number of properties. Cesspools perform no effluent treatment thus represent a significant hazard to the aquatic environment if not managed in an appropriate manner. As expensive off-site emptying and waste processing is required, stringent monitoring is necessary to reduce illegal draining. Should illegal effluent release occur, large nutrient loads might be released and ecological interest features within the receiving waterbody may be at risk from habitat disruption.

Cesspool dimensions may vary on an inter-site basis, however a maximum depth of 4m is permitted. Cesspools are prohibited for use in Scotland or Northern Ireland and are the least desirable option, generally used when septic tanks are deemed inappropriate (i.e. when ground water resources must be protected) Cesspool construction is rigorously controlled and regulated by the relevant Local Authority (LA) from whom planning permission has to be granted in advance. Before installation of cesspool, it is recommended a feasibility study be undertaken to ascertain economic cost of cesspool maintenance. An average three person household produces 7m^3 of waste in a 3 week period, this is the average capacity of a typical transport tanker thus 17 journeys per annum would be required, incurring significant financial costs (BS6297). As access for a heavy vehicle is required within 30m of cesspool they may not be suitable for isolated rural areas with poor infrastructures. Stringent guidelines are applied to the management and operation of cesspools, capacity is governed by British Standard 6297 and must have a minimum volume of 18m3 (max = 50m^3). All brickwork needed to secure the tank should be >229mm thickness, whereas any concrete used in construction must be >150mm thick. If cesspool is to be situated in waterlogged ground, firm moorings must be provided as the tank must not float under any circumstances. To inhibit water intrusion, cesspools should be provided with adequate roofing and an access point must be included to aid inspection and maintenance. Construction materials must be electrolyte resistant where necessary. Suitable ventilation is mandatory, and access to horizontal inlet pipe should be provided.

Fresh air inlets with non-returnable flap, must be provided with a minimum diameter of 100mm and extend to a minimum of 800mm above ground level. Cesspools should be located away from inhabited buildings (>15m) and preferably down slope of households.

1.1.2 Septic Tanks

A septic tank is a compartmentalised watertight tank, or a series of tanks, that facilitate primary settlement and a degree of secondary biological treatment under anaerobic conditions. The effectiveness of septic tanks depends on numerous factors including frequency of cleaning, frequency of emptying, temperature and size of tank. Providing manufacturers instructions are followed, septic tanks produce an effluent of reduced potency, reducing strength of sewage by up to 70% (Dee and Sivil, 2001). Septic tanks collect wastewater from the property (point A, figure 1.1), transporting it to a central chamber for processing (point B, figure 1.1). Dependant on composition of the receiving ground, the effluent may be permitted to discharge into land drains/soakways (point C, figure 1.1). If a higher quality effluent is required (e.g. 30 mg/l suspended solids: 20 BOD^5 mg/l O_2) biological filtration should be used in conjunction with a conventional septic tank; examples of these are given in sub-section 1.1.4.3.

Providing de-sludging is performed at least once per annum, required capacity is derived from BS6297 and is given by:

$$C = (180P + 2000)$$

where:

C = capacity of tank (l)
P = population served

A cross section of a typical septic tank is show in figure 1.2. When a compartmentalised septic tank is used, the primary settlement area must have a volume of 2/3 C, other areas must have combined capacities of at least 1/3 C. In order to minimise discharge of solids in effluent, utilising tanks in series is favourable. Individual compartments should have a depth greater than 1200mm below top water level (up to 10 persons) and greater than 1500mm for larger populations. The primary settlement compartment should have a length twice the width, and for septic tanks designed for larger populations, a baffle (device which promotes uniform flow) may be required at the inlet, whilst a scumboard (device to retain scum) should be installed at the outlet. To aid desludging, the primary settlement chamber floor should slope at approximately 1:4 towards the inlet.

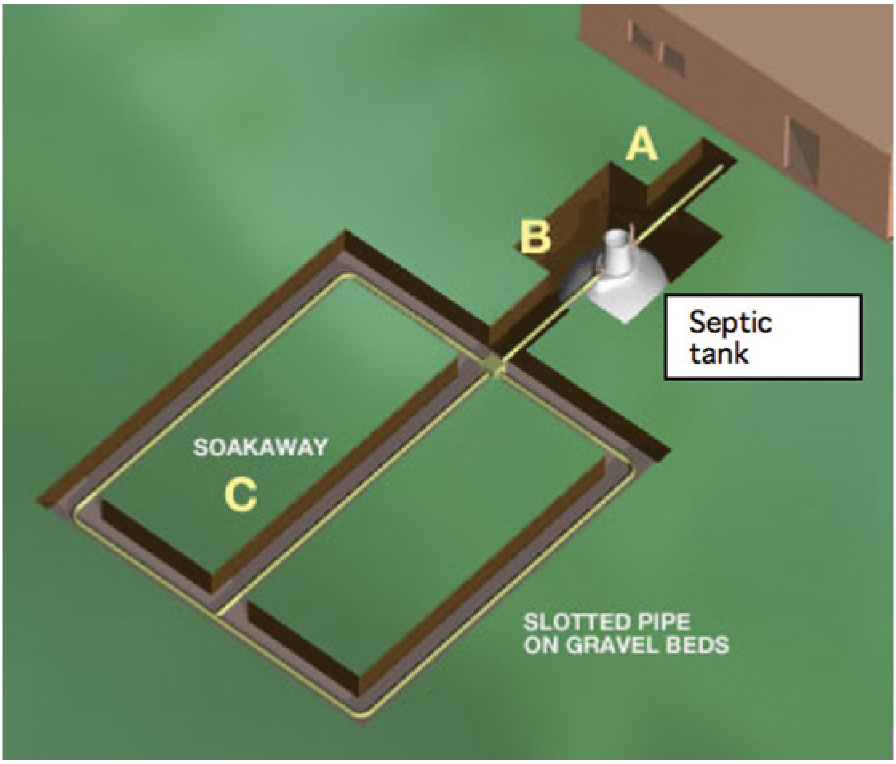


Figure 1.1. Typical septic tank set up; (c)Southern Drainage 2007

Figure 1.2. Septic tank cross section; (c)Southern Drainage 2007

For populations up to 30, arrangements similar to those illustrated in figures 1.3 (pp.7; using two tanks in series) or 1.4 (pp.7; two tanks combined in a single unit) would be suitable. Figures 1.5 (pp.8) and 1.6 (pp.8) show arrangements that would be suitable for populations greater than 30 persons (separate and combined systems shown respectively). As with cesspools, an adequate roof should be provided, and tanks should be fenced off preventing unauthorised access. If the p.e. >60, two tanks, each with two compartments, should be used in parallel (each of which must be at least 50% of total required capacity) allowing desludging operations to be carried out in one, whilst other is operational. As flow surges are of reduced significance at septic tanks >100 p.e., two single chamber tanks may be used in parallel in these situations. Inflows and outflows should be designed to minimise disturbance of settled sludge (details of inflow and outflow design can be found in BS 6297). Installation of a septic tank is tightly controlled and requires Local Authority consent.

In order to maintain septic tank performance, household water use should be kept to a minimum, with little use of disinfectant or detergents (Payne and Butler, 1993). Inappropriate use, mismanagement or unsuitable design may cause significant problems in septic tank operation (table 1.5, pp.8) and have adverse ecological effects. Such problems include production of offensive odours (often caused by bacterial die off due to overuse of disinfectants; Payne and Butler, 1993), surface/groundwater contamination, backing up of sewage in households and surface ponding. In order to minimise these problems, a project management plan, such as those shown in section 3 (pp?), should be actioned.

Treated effluent may be dispersed either the ground via a constructed soakway/ drainage system, or directly to a local watercourse. Percolation tests should be run on proposed soakway soils to determine their suitability. If the receiving ground is relatively impermeable, it may be necessary to install sub-surface irrigation systems. If local discharge is not permissible effluent may be transported off-site for emptying.

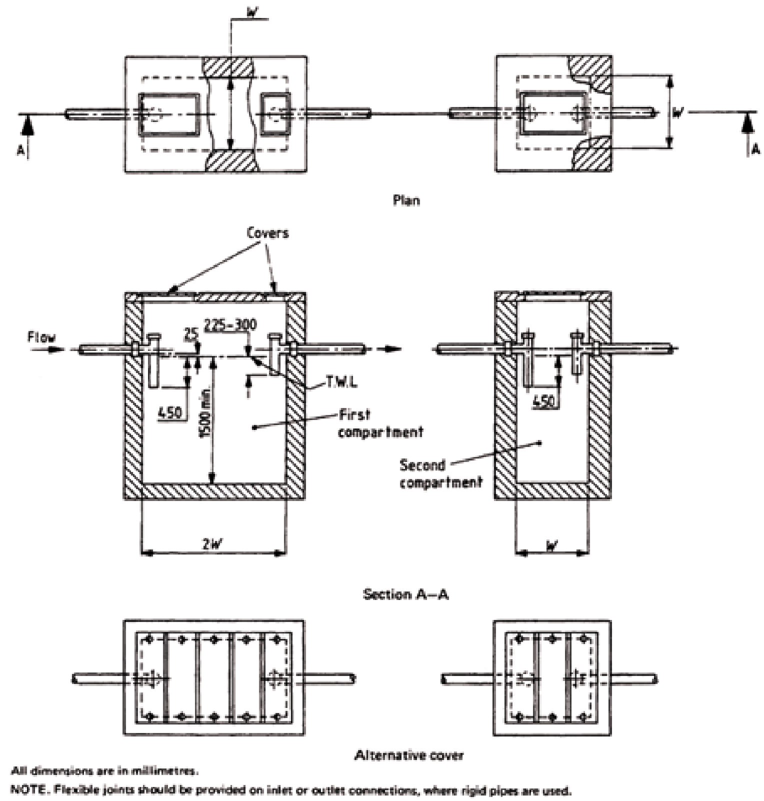


Figure 1.3. Two septic tanks in series for populations up to 30 persons

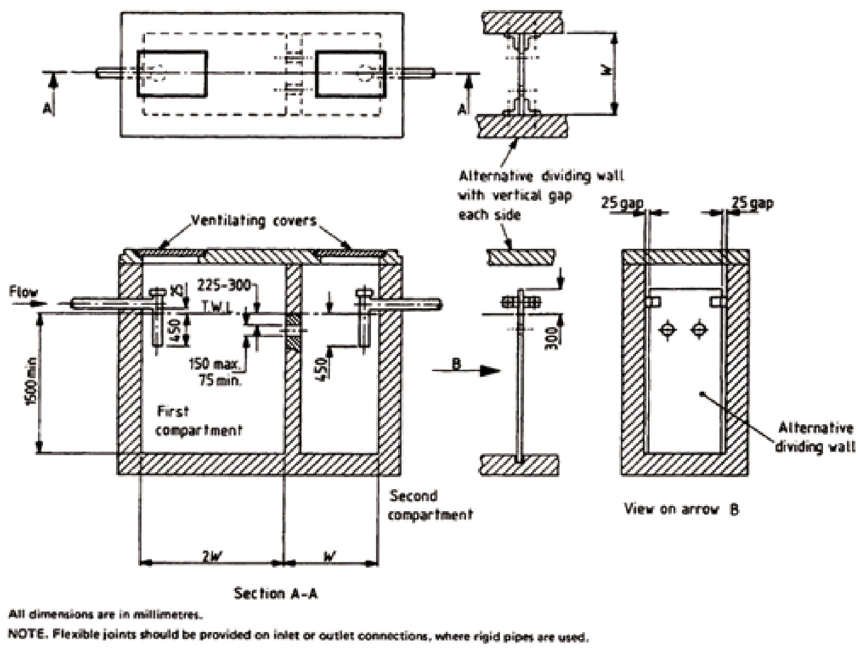


Figure 1.4. Two septic tanks combined for population up to 30 persons

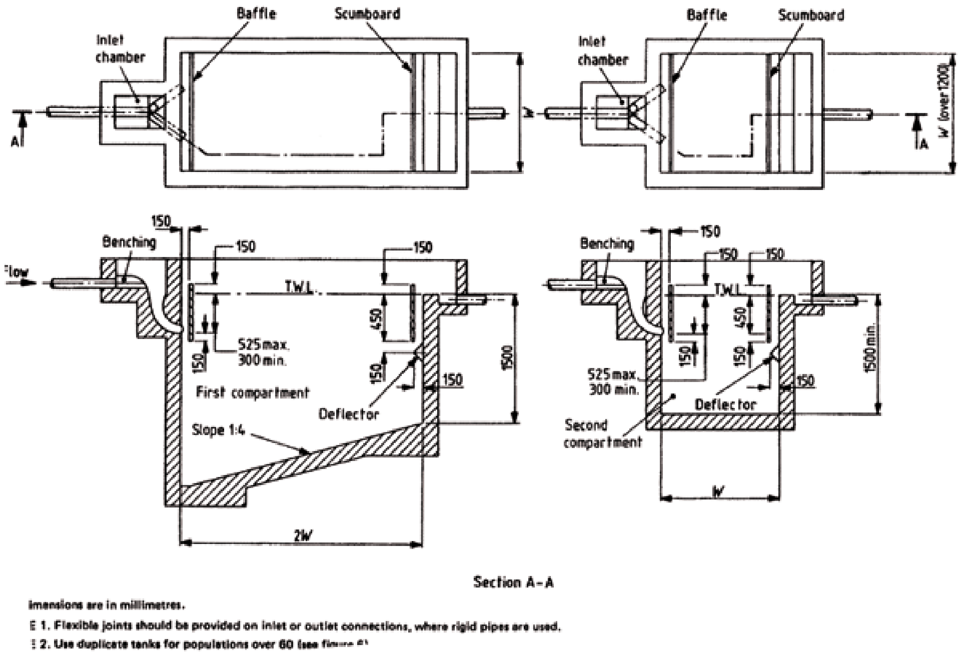


Figure 1.5. Two septic tanks in series for populations over 30 persons

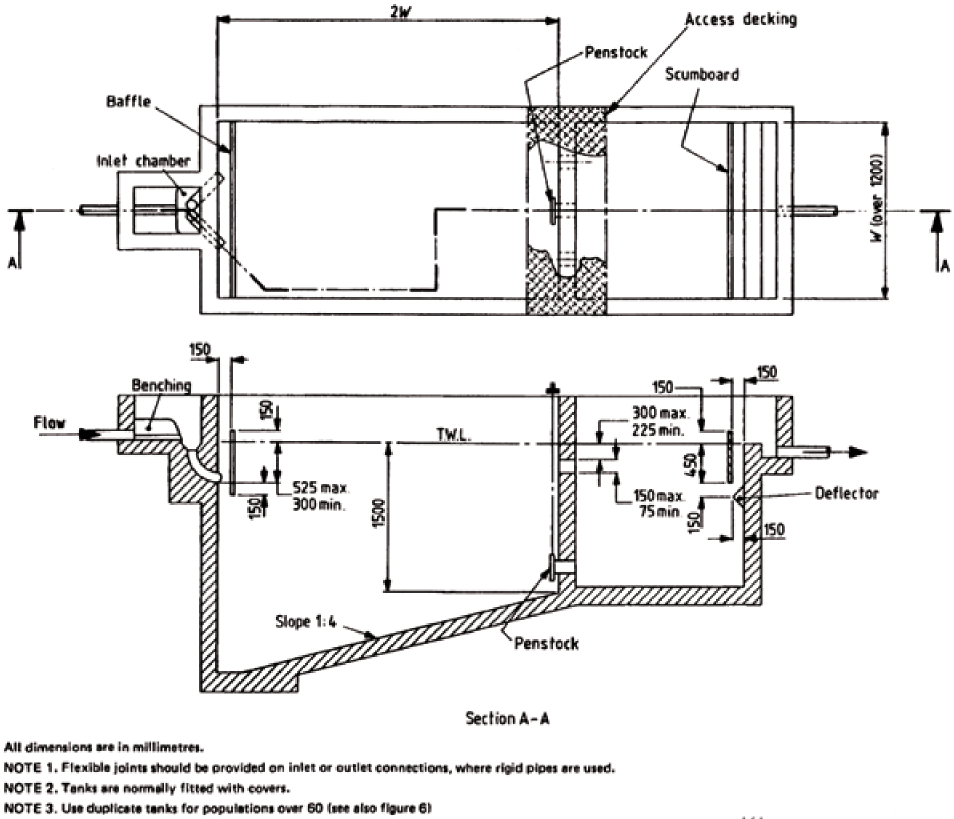


Figure 1.6. Two septic tanks combined for population over 30 persons

Table 1.5. Symptoms and immediate causes of septic tank problems (Payne and Butler, 1993)

Symptom	Immediate cause
Odour	Inadequate ventilation of drains Blocked drainage field Inadequate drainage field
Backing up of sewage	Sagging or blocked inlet drains Blocked drainage field Inadequate drainage field Tank full of sludge
Surface flooding	Sagging or blocked inlet drains Blocked drainage field Inadequate drainage field Tank full of sludge
Solids discharged from tank	Tank full of sludge Inefficient or undersized tank
Local watercourse pollution	Blocked drainage field Inadequate drainage field Tank full of sludge Deliberate overflow connection made Proliferation of tanks discharging to land which quickly drains to watercourse
Tank full of groundwater/ tank rises from ground	High water table
Groundwater pollution	Drainage field operating properly but system in unsuitable location Proliferation of tanks in sensitive area

1.1.3 Modern packaged sewage treatment plants

Modern package plants are those that are prefabricated, and can be assembled on site with relative ease. Usually containing primary sedimentation, filter beds (air injection or rotating discs), and a secondary settlement stage, modern package plants are available in a range of process configurations capable of producing a high standard effluent. Domestic wastewater is fed from properties to the package plant (point A, figure 1.7, pp.10), where it is subject to primary settlement and aerobic biological decomposition (point B figure 1.7 and figure 1.8, pp11). Package plants are available in a range of options (common package plants are shown in table 1.6, pp12) and the most common in the UK are:

- activated sludge units;
- extended biofiltration;
- rotating biological contractors.

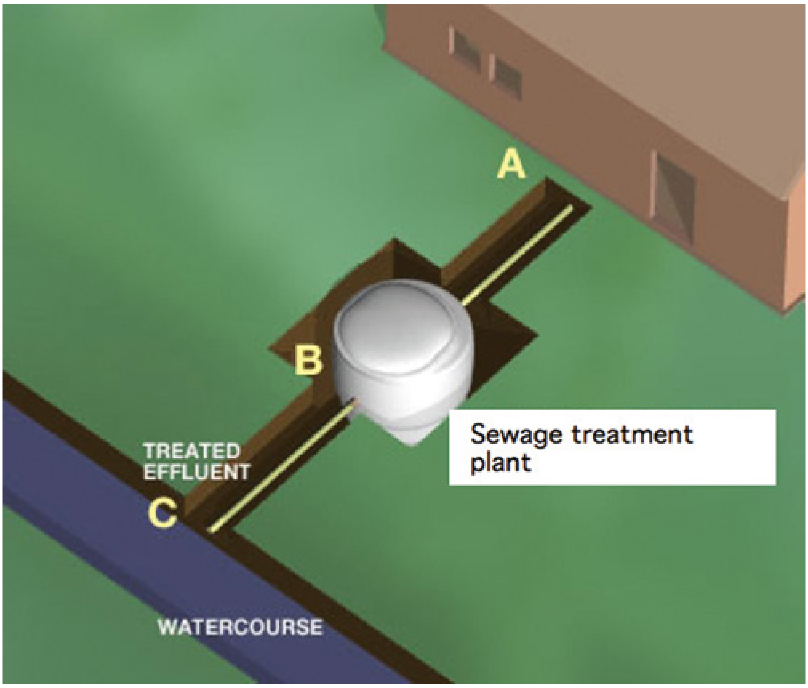


Figure 1.7. Typical package sewage treatment plant set up; (c)Southern Drainage 2007

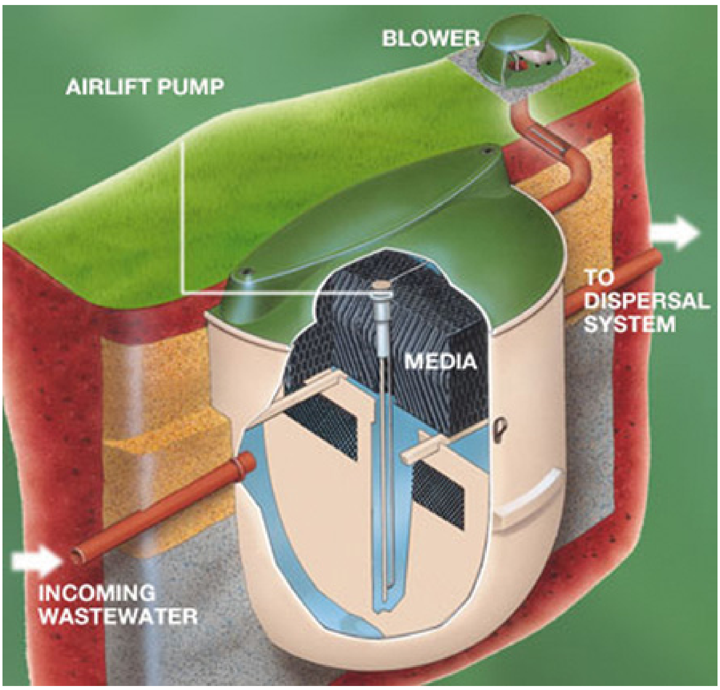


Figure 1.8. Package sewage treatment plant cross section; (c)Southern Drainage 2007

Table 1.6. Features of small sewage treatment plants (adapted from Payne and Butler, 1993)

Type of plant	Size range	Advantages	Disadvantages
Activated sludge: Contact stabilisation	30 – 20,000 p.e.	No primary sludge formed. Secondary sludge partly stabilised and low quantity. No odour. Compact. Reserve activated sludge always available. 30:20 effluent can be achieved.	Regular power and maintenance required for aeration and pumping. Power failure can be serious. Surge flows can cause loss of activated sludge. Noise can be a problem.
Activated sludge: Extended aeration	17 – 30,000 p.e.	No primary sludge formed. Secondary sludge partly stabilised and low quantity. No odour. 30:20 effluent can be achieved.	Highest power requirement of all types. Regular maintenance required for aeration and desludging. Regular inspection advised.
Extended biofiltration	15 – 450 p.e.	No primary sludge produced. Can treat intermittent flow. Compact plant possible. 30:20 effluent can be achieved	Some odour problems likely. Final sludge is difficult to dewater. High power requirements. Efficient operation depends on reliable power supply, regular inspection and maintenance.
Rotating biological contractor	5 – 40,000 p.e.	Power consumption and head loss requirement both low. 30:20 effluent can be achieved. Inconspicuous. Fly nuisance can be eliminated.	Sludge removal and motor maintenance required every three months. Sensitive to overloading. Power failure causes total loss of efficiency
Oxidation ditch		Can be operated as extended aeration plant, maintenance is similar but simpler. Can be flexible in loading capacity. 30:20 effluent can be achieved.	Not economical in land area required but can be economical in power consumption. Regular maintenance required for aeration and desludging. Regular inspection advised.

Should biological treatment be used in the package plant, it may be necessary to install secondary settlement (humus tanks) in order to remove detritus. These should be placed directly after biological treatment. In some package plants, secondary sludge is transferred to primary settlement tanks for storage and disposal with pre-treated sludge. Regular maintenance by qualified persons is essential to maintain high performance. Maintenance required will vary greatly depending on the process options selected, for example activated sludge units are complex and may require a significant investment of time and money to ensure sustainability. Dependent on discharge consents set by the environmental regulator, the final effluent may be discharged into a land drain, lake, river etc (point C).

1.1.4 Small sewage treatment works

In situations where package plants are not suitable and there is no connection to mains sewers available, small STW may be the most efficient and economical solution. Procedures and process options are similar to those used at large mains connected STW, and are briefly presented in the following sub-sections.

1.1.4.1 Preliminary treatment

Before influent can undergo primary settlement, it is necessary to remove large grit and floating debris that can damage STW machinery. Various methods of influent screening are used, the most common being:

– macerator located in the inlet pipe/channel;

– screens with 30-75mm spacing between vertical bars.

Debris removed during the preliminary treatment stage may be put into landfill sites, and the screened influent will be routed to the primary settlement tanks.

1.1.4.2 Primary treatment

The aim of primary treatment is to promote settling of the influent and removal of gross solids, producing an effluent of reduced strength and allowing more efficient secondary processing of the supernatant liquid. A typical rural primary settlement tank is shown in plate 1.1 (pp.13) Primary settlement tank efficiency is highly dependent on incoming flow velocity, which is in turn controlled by tank dimensions. Flow variations characteristic of small STW will significantly reduce settlement efficiency thus primary settlement tanks are usually used at STW with >100 p.e. For STW <100 p.e., the primary settlement stage may be omitted, with sewage being directed straight to the biological treatment phase. Two types of primary settlement tanks are commonly used, upward flow and horizontal flow. Upward flow tanks tend to be more expensive to construct and install, but have a number of advantages:

- hydrostatic desludging means that the need for two parallel tanks is eliminated;
- manual sludging is not required, improving safety.

Sludge should be removed at regular intervals (usually at least once per week), as build up will reduce tank capacity and efficiency. Due to the high proportion of fats, oils and grease in domestic waste, scum retention boards should be used at tank output points. Upward flow tanks (figure 1.9, pp.13) are usually square in plan view with a sloping bottom to aid sludge settlement and storage. Horizontal flow tanks (figure 1.10, pp.14) tend to be rectangular in plan with a length 3 times the width, depth should be 1500mm below top water level.

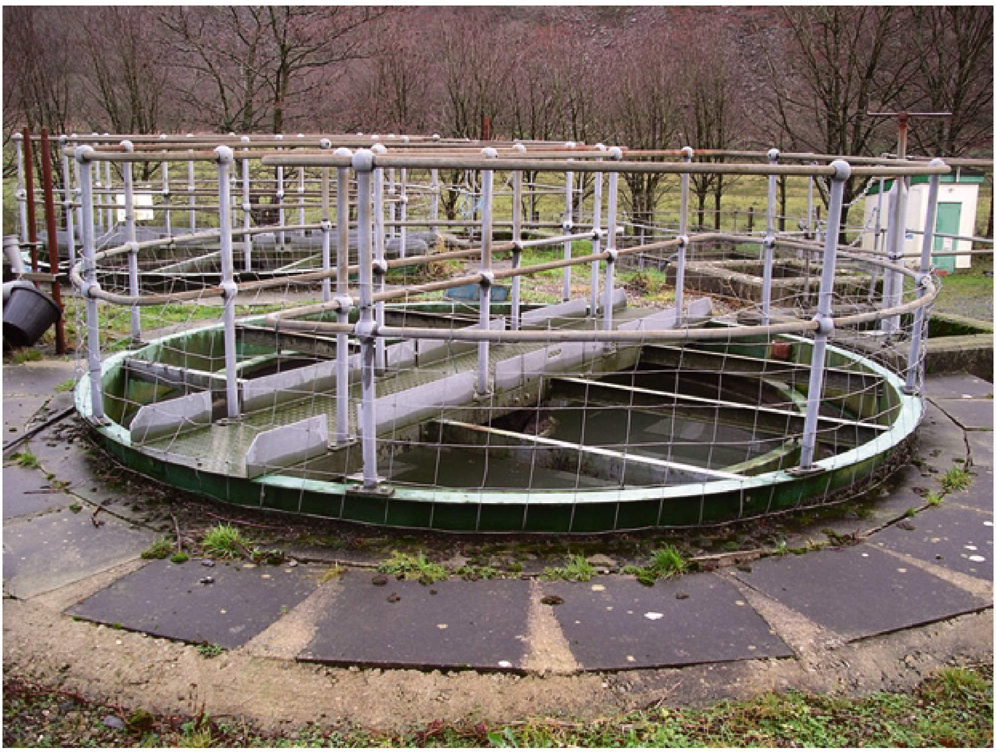


Plate 1.1. Primary sedimentation tank at a rural STW

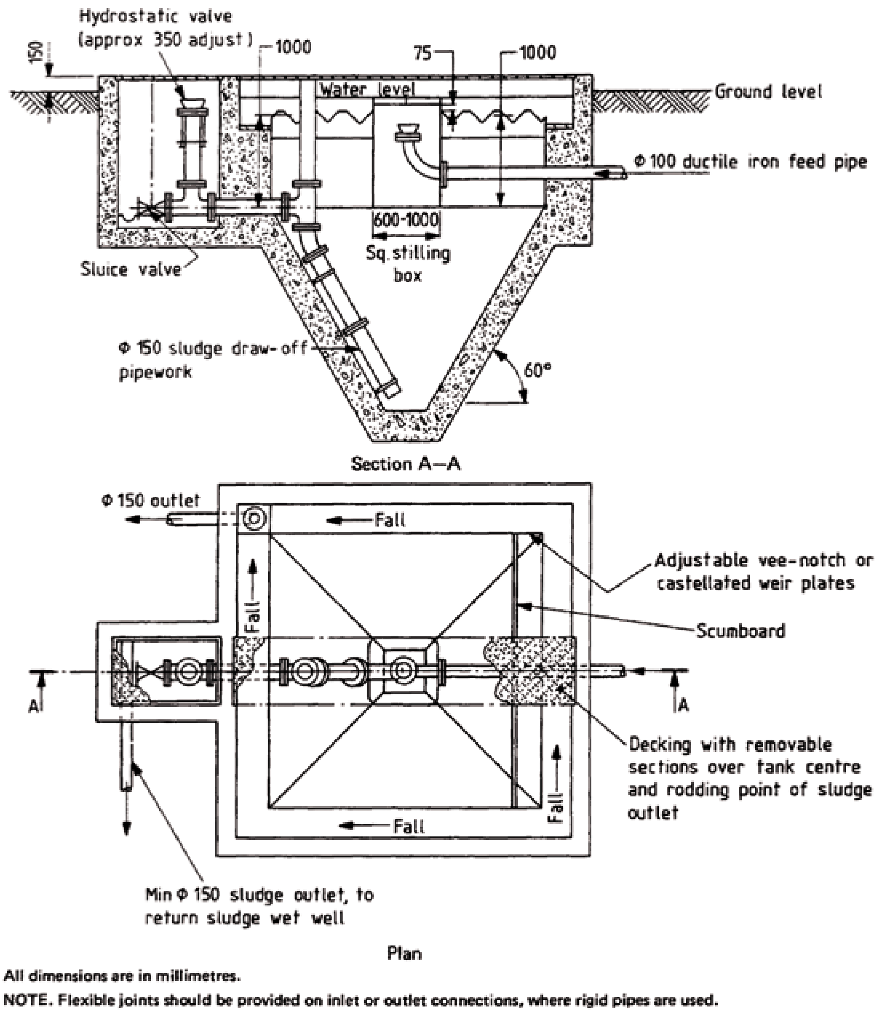
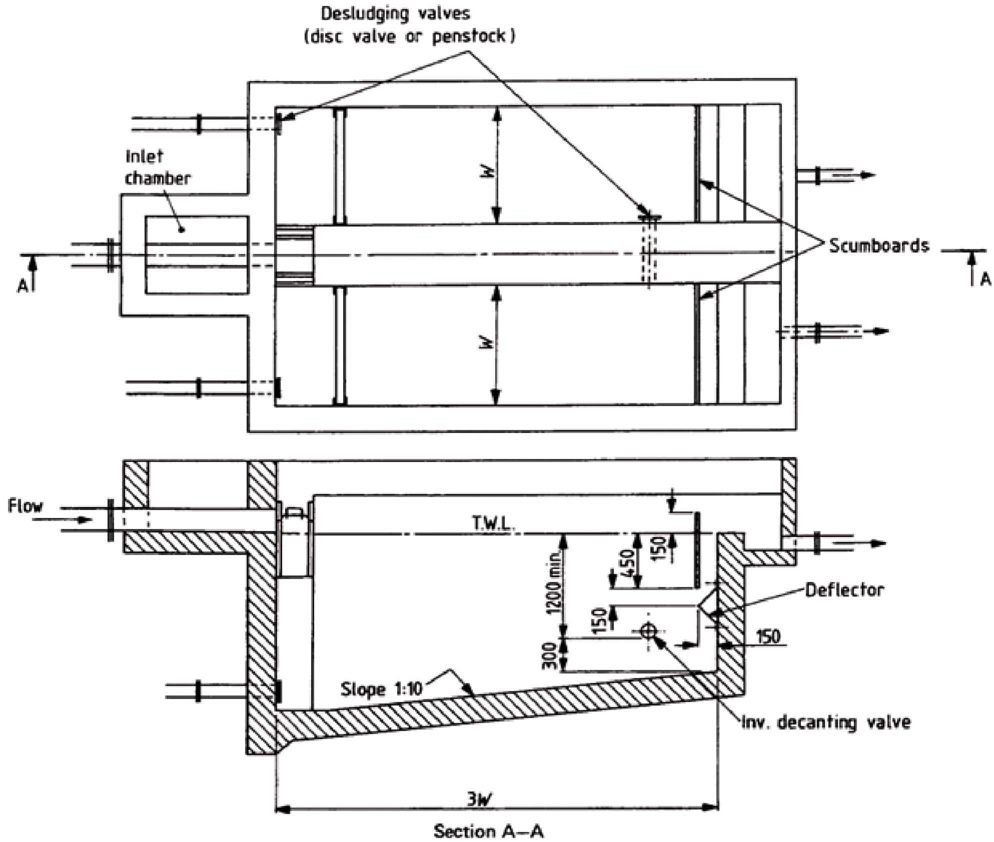


Figure 1.9. Typical upward flow settlement tank

The floor of horizontal settlement tanks should have a slope of 1:10 towards the inlet, and two tanks must be operated in parallel, to allow desludging. Choice of either upward flow or horizontal flow will depend on a number of economic and practical factors.



All dimensions are in millimetres.
NOTE. Flexible joints may be required on inlet or outlet connections, where rigid pipes are used.

Figure 1.10. Typical horizontal flow settlement tank

The flow velocity in an upward flow tank must be less than the settling velocity of the liquor and 0.9m/h at maximum flow rate is given in BS6297. Required hopper dimensions will vary on an inter-site basis, general designs are illustrated in figures 1.9 and 1.10 (further details can be found in BS6297).

1.1.4.3 Biological treatment

The liquor, which has already undergone primary settling, is introduced to a biological film, grown on a suitable medium utilising oxidising micro-organisms to breakdown matter. Various forms of biological filter are in use in the UK, all of which require suitable ventilation and drainage. The most common types of biological treatment units are:

– **Conventional biological filters**

Usually either rectangular (figure 1.11, pp.15) or circular (figure 1.12, pp.16 and plate 1.2, pp.16) biological filters process liquor as it percolates from the surface to base of the unit. Liquor must be evenly distributed over the surface of the unit, and is usually spread via a rotating arm or a series of fixed channels. Fixed channel distribution systems are usually limited to STW <50 p.e., whereas rotating arm distribution systems are suitable for a wide range of populations. In very isolated rural areas rotating arm distribution systems may be unsuitable due to the required power supply, needed to power rotation of arm. Either mineral or plastic media may be used in biological filters and choice will be dependent on financial and practical costs. After treatment through conventional biological filters, effluent is suitable for discharge to gently sloping grassland (1:60 - 1:100: see sub-section 1.1.5.1, pp.17), that removes humus and can then be collected in a system of receiving channels;

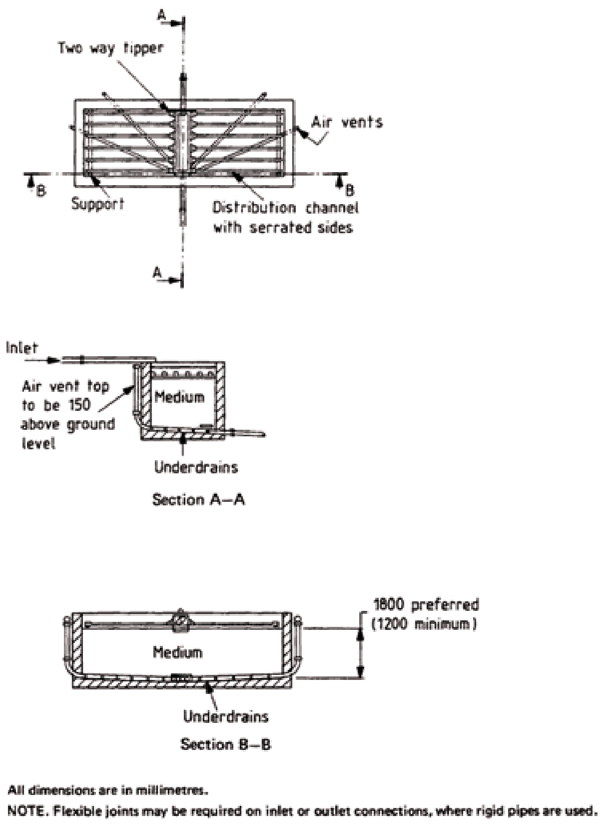


Figure 1.11. Typical conventional biological filter (rectangular)

– **Rotary biological contactors**

Micro-organisms are housed on a rotating disc (usually expanded metal, plastics mesh, high density polystyrene foam, GRP or un-plasticised polyvinyl chloride) that exposes them alternately to air and sewage, allowing oxidation to take place. Treatment is maximised when longitudinal mixing is minimised and microbiological film shed from the disc is transported to the secondary settlement chamber. Rotation speed (in the order of 1 r/min - 3 r/m) and disc diameter control the peripheral velocity, which should be kept below 0.35m/s in order to prevent removal of microbial material. Secondary settlement tanks should provide storage for 3 months accumulation of humus sludge and if a high standard effluent is required, loading rate should not exceed 5g BOD per m^2 per day (settled sewage) or 7.5g BOD per m^2 per day (crude sewage).

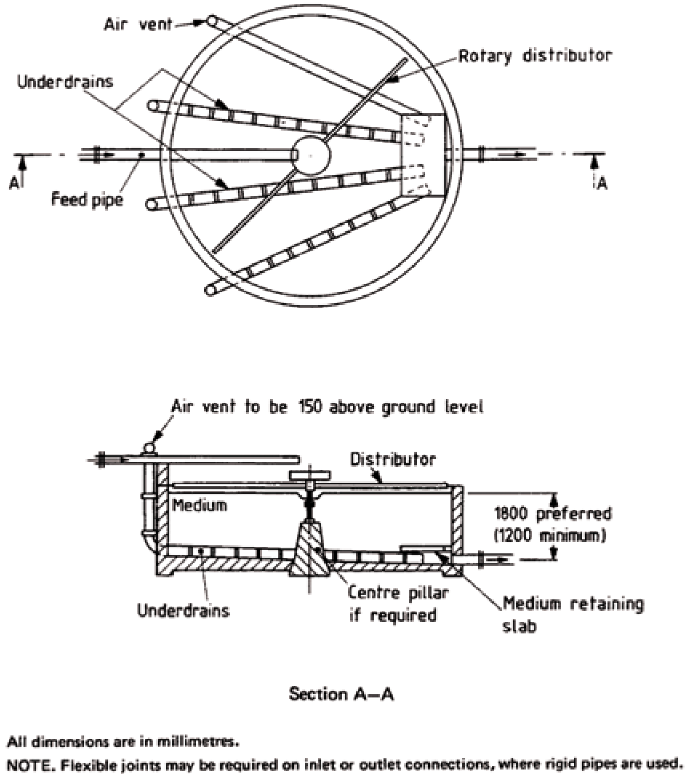


Figure 1.12. Typical conventional biological filter (circular)

Plate 1.2. Biological trickling filter at rural STW

1.1.4.4 Activated sludge units

Activated sludge units process crude unsettled sewage utilising long aeration periods in order to oxidise the sludge, thus reducing sludge volume. Three types of activated sludge plants are commonly used in the UK:

– **Extended aeration**
Usually pre-fabricated factory produced units suitable for up to 25 persons. Two compartments are used, an aeration (mixed liquor) chamber and a settling compartment. Sewage must undergo preliminary treatment prior to introduction to the aeration chamber where it is mixed with activated sludge. Sludge is disassociated from the mixed liquor in the settling compartment and is returned to the aeration chamber. The supernatant liquid is then transported over a weir and disposed of in an appropriate manner. Capacities of 230L per capita are common, and minimum retention time is 24h. Maximum BOD loading should be between 0.05 - 0.15 k/day;

– Contact stabilisation

Suitable for populations >70 persons. Preliminary treated liquor is processed in 4 sequential compartments:

- aerated in contact with activated sludge for 30-120 mins;
- settled in second compartment;
- supernatant liquor is re-aerated for a longer period, >120 mins. Activated sludge may then be recycled to first compartment;
- transported to a further aerobic digestion compartment where excess sludge is oxidised;

– Oxidation ditches

Comprised of a uniform oval shallow channel (1m-3m depth) equipped with a number of mechanical aerators, to maintain velocity. If ditch is in continuous use, additional settling facilities will be required.

1.1.5 Tertiary treatment

Although the process options listed above may produce an effluent reaching a 30:20 (SS: BOD) standard, even higher quality effluents may be produced by 'polishing', or subjection to tertiary treatment. Techniques utilised include sedimentation, flocculation, and filtration; at STW >10,000p.e., nutrient stripping technology may be employed (this is discussed in section 5). Polishing techniques will only be effective where an efficient secondary biological treatment system is employed, and in these cases a 10:10 standard may be achieved. Methods employed at small and large STW differ greatly, presented below are the systems likely to operate at small/rural STW.

1.1.5.1 Grass plots

Grass plots can prove to be inexpensive, and be capable of removing up to 50% of BOD and up to 70% of suspended solids. A typical treatment grass plot is shown in figure 1.13 (pp.18). Suitable area per head is $3.0m^2$, and a slope of around 1:60 - 1:100 is preferable.

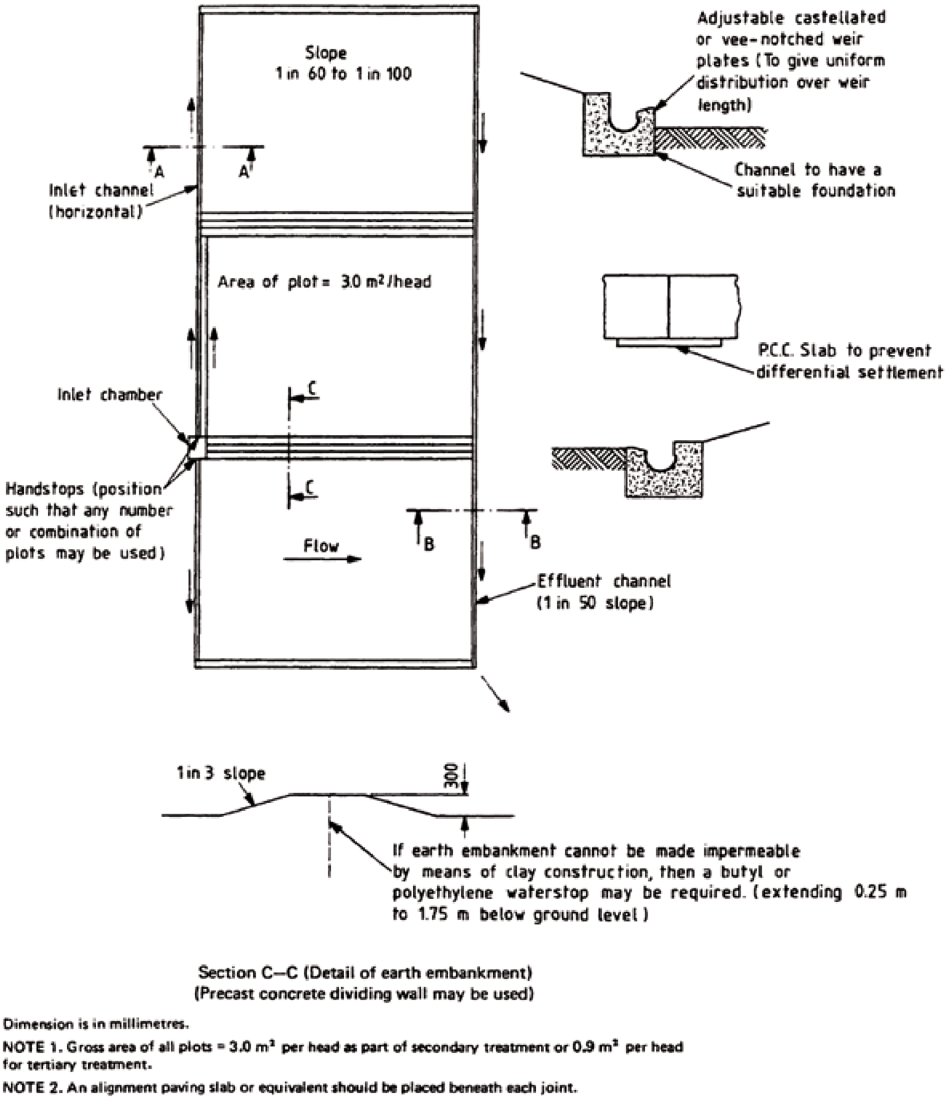


Figure 1.13. Typical grass plot for sewage treatment

1.1.5.2 Upward flow clarifiers

Effluent is transported upwards through a bed of gravel approximately 5-7mm deep that rests on a perforated floor (figure 1.14, pp.19). Flows through the gravel bed should be <1.0 $m^3/(m^2 \cdot h)$ and under favourable conditions, approximately 30% BOD and 50% suspended solids can be removed provided gravel bed is regularly cleaned. If possible, two gravel beds should be used in parallel, allowing the removal of one bed for full cleaning.

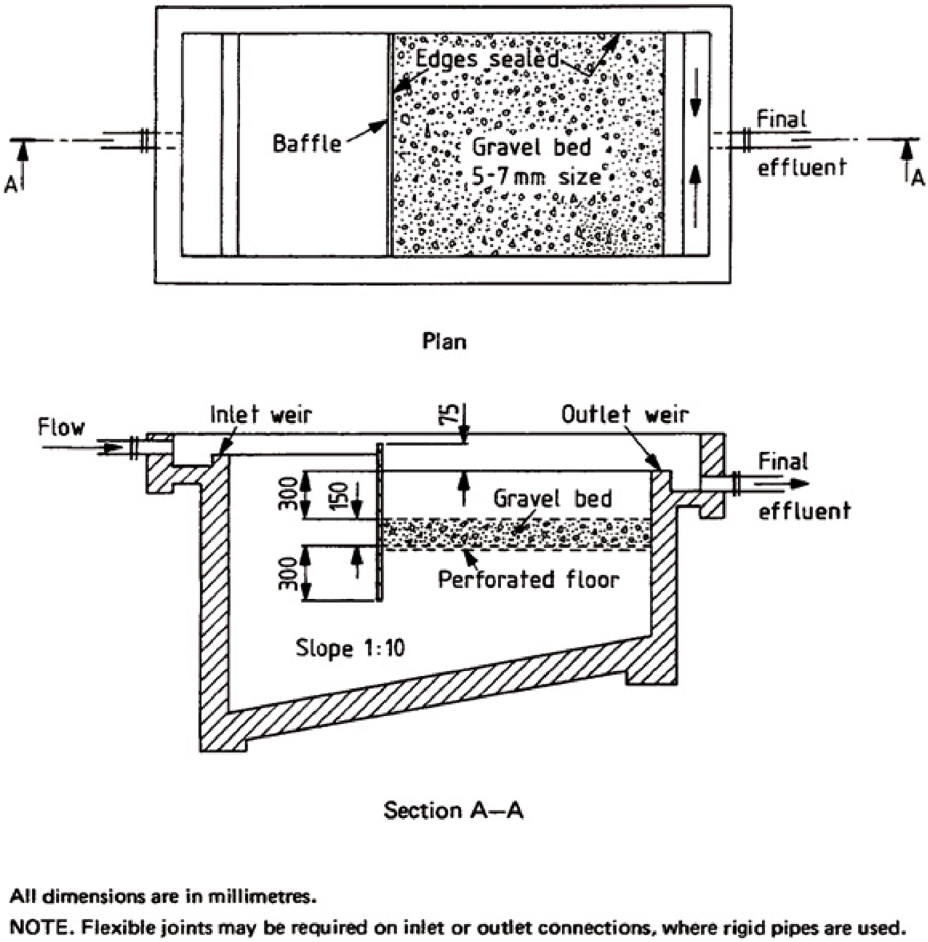


Figure 1.14. Typical upward flow clarifier

Gravel beds should be 'backwashed' with either freshwater or effluent regularly in order to maintain performance. Baffles should be utilised to maintain uniform flow beneath the gravel bed, promoting efficiency. If gravel usage is deemed unsuitable, metal or plastic meshes may be used, providing they are not structurally vulnerable.

1.1.5.3 Effluent lagoons

The main function of effluent lagoons is to remove any remaining suspended solids, whilst facilitating further biological oxidation (environmental conditions permitting, i.e. sunny and warm). Retention times are typically between 4 and 6 days after which BOD may be reduced by 40% in conjunction with up to 70% reduction of E. Coli. Soil on which lagoons are situated must be relatively impervious, and it is recommended that length is three times the width of the lagoon ensuring plug flow conditions. A minimum depth of 1.5m is required in order for lagoons to be effective and baffles at inlet points should be installed to ensure uniform flow.

1.1.5.4 Reed bed treatment systems

Reed beds are a 'natural treatment system' relying on biological processes to treat sewage effluent. Household sewage is first settled in a septic tank, removing gross solids, and subsequently processed by either a horizontal or vertical flow reed bed (plate 1.3). Utilising specially reared reeds (e.g. Phragmites australis) that promote biological purification, reed beds can produce a high standard effluent. Reed bed systems require larger sites than the aforementioned tertiary treatment options thus may be suited to rural areas. Again, Local Authority and Environment Agency consent is required. Detailed information regarding the use of reed beds is given in section 4.

Plate 1.3. Typical reed bed treatment system (c)YES Reedbeds 2007

1.1.6 Effluent disposal

After effluent has been treated in one of the manners described in the above sub-sections, careful disposal is required to ensure it causes no detrimental ecological effects within the receiving watercourse. There are currently a number of disposal methods used in the UK all subject to licence by the relevant authorities:

– **Disposal to inland or tidal water**
Size and timing of discharge has to be agreed with the environmental regulator;

– **Disposal to underground strata**
Discharges to porous subsoils (e.g. gravel, chalk or sand) above the winter water table may require installation of a soakway pit (a hole filled with large pieces of material, or lined with porous concrete or brickwork) to facilitate effluent percolation. If so, the pit must be adequately covered and must include an inspection hatch. Surface irrigation systems consisting of a network of field drains constructed from porous/perforated pipes may be required in less porous subsoils. Sub surface pipes must be >500mm below the ground surface and percolation tests should be performed to ascertain subsoil properties, details of such tests can be found in BS 6297;

– **Disposal to land**
Effluent is spread evenly over a predetermined treatment area that divided into two sectors allowing rotational use. Up to 100 m^2 per person is required. Effluent is clarified by seepage into the ground and by evapotranspiration. As with disposal to underground strata, a percolation test must be performed before any effluent release occurs.

In conjunction with the disposal of liquid effluent, the sludge must also be disposed of in a suitable manner. Firstly the sludge must be dried, this is typically done either on a sludge drying bed, or at a dewatering plant with the process usually taking 6-10 weeks. Air-drying may take place on an under-drained clinker ash or grit-sand bed allowing for simultaneous evaporation and drainage; 0.4m^2 bed should be allocated per capita and maximum sludge depth is 225mm. If on-site treatment of sludge is not appropriate, it may be transported via a tanker to a larger STW for processing.

1.1.7 Extent of methods

As table 1.7 indicates, the number of households relying on private sewage processing and disposal is small. The majority of houses that are not connected to STW via the mains sewerage network are connected via a privately owned sewer (see sub-section 1.2.1). The predominant method of sewage treatment for households processing their own waste is septic tank. The data indicates that cesspool use declined over the study period and are no longer used.

Table 1.7. Drainage attributes in non-mains households by construction date (Anon, 2003)

Type	Pre 1945	1945-1990	1991-2001
Mains connection	95.9%	98.9%	97.8%
Septic	3.0%	0.8%	1.7%
Cesspool	0.7%	0.1%	0.0%
Private STW	0.3%	0.1%	0.3%
Unknown	0.1%	0.1%	0.2%

Note: Mains indicates private sewer connected to public sewer.

Where package plants are used (0.3% of non-mains households), it is thought that activated sludge units are the most popular, followed by rotating biological contractors (Dee and Sivil, 2001). The only available data for the scale of septic tank and private STW usage is from 1993, and indicates that there are around 35,000 septic tanks in the UK (table 1.8). As septic tank and package STW are not separated it is not possible to estimate the number of STW.

Table 1.8. Sewerage in England and Wales (adapted from Payne and Butler, 1993)

Region	% Sewered	Unsewered properties (000s)	Approximate consents[(1)] 000s	EA estimate[(2)] 000s
Anglia	93	167	10	-
Northumbrian	98	21	-	5
North West	98	55	1	-
Severn Trent	97	100	7	70
Southern	95	90	-	30
South West	88	70	-	20
Thames	98	94	4	-
Welsh	93	93	-	-
Wessex	93	72	-	50
Yorkshire	97	57	-	10
ENGLAND AND WALES	96	819	35	-

1 Figures are estimates and apply to septic tanks only
2 Figures are estimates and apply to septic tanks and package sewage treatment works

Figures given in table 1.8 are maximum estimates and as more recent data are unavailable for analysis, trends cannot be identified. This data shows that the largest number of both septic tanks and unsewered properties are in the Anglian and Severn Trent regions, whilst the south-west region had the highest percentage of unsewered properties. Although the number of residential properties isolated from the mains sewerage network is small, table 1.9 indicates there are a significant number of industrial properties that remain unconnected.

Table 1.9. Industrial sector discharges not connected to mains sewerage (Defra, 2006)

Sector Industry	p.e	Number of plants	Total p.e. meeting required standards 31.12.2000	compliance %	Full compliance by
Milk processing	1,464,380	30	644,880	44	Dec-03
Fruit & Vegetables	1,144,564	9	1,144,564	100	Dec-00
Potato processing	302,037	3	302,037	100	Dec-00
Meat industry	623,348	18	573,348	92	Dec-01
Breweries	94,000	1	94,000	100	Sep-97
Alcohol production	1,930,727	23	1,930,727	100	Dec-00
Animal feed	476,000	3	476,000	100	Dec-00
Glue and gelatine	13,315	1	13,315	100	Dec-00
Malt-houses	206,666	9	206,666	100	Dec-00
Fish processing	18,000	2	5,000	28	Feb-01
TOTAL	**6,273,037**	**99**	**5,390,537**	**86**	

Whilst the overall compliance is good (86%) it can be seen that the milk and fish processing industries are failing to meet targets by a significant margin, hence drastically reducing overall compliance level. Higher resolution data were not available for analysis, and locations of non-compliant plants could not be identified for further investigation. However it may be assumed that as many of the industries listed are agricultural, they may be located in rural areas, presenting a risk to aquatic ecosystems.

1.2. Current practices and methods available for the treatment of mains connected rural wastewater in the UK

The majority of households located in rural areas are connected to the main sewerage network with waste being processed by the relevant regional water and sewage company for which charges are levied against the user (Dee and Sivil, 2001). Depending on size of rural community to be served, a number of process configurations are available, tailored to provide the most sustainable and economic solution. An exhaustive discussion of process configurations would not be beneficial and in most cases the theory is similar to those illustrated in sub-sections 1.1, albeit at a larger scale. Many households in rural areas are connected to the mains network by private sewers (i.e. structures not owned by one of the ten major water and sewerage companies). In such situations it is the responsibility of the property owner to manage and maintain sewers, ensuring compliance with all relevant environmental legislation. The following sub-section illustrates the extent of private sewers and problems that may arise from neglect or misuse.

1.2.1 Private sewer systems

There are approximately 9,450,000 properties served by private sewers in the UK of which it is estimated 7,097,500 (75%) are located in rural areas (Anon, 2003). A significant proportion of the private sewer network is in an unstable condition (table 1.10) and likely to malfunction. 45% of private sewers are in a condition susceptible to deterioration, whilst a further 17% are at significant risk of failure. Any breakdown of the network could cause sub-standard effluent release into ecologically sensitive rural areas, damaging floral and faunal populations in the receiving waterbody. Private sewers are also problematic as it is often unclear whose responsibility it is to maintain and replace them, thus furthering the potential for deterioration (table 1.11). As table 1.11 illustrates, there are a significant number of private sewer faults per annum, the English House Condition Survey (in Anon, 2003) indicated there were a total of 282,000 internal and external-flooding incidents per annum associated with all private sewers. However, Local Authorities only recorded 120,000 sewer related flooding incidents, whilst Ofwat only recorded 5,700 internal flooding incidents. Therefore, it is likely many sewer faults are not reported, limiting the chance of exercising damage mitigation strategies.

Table 1.10. Condition of private sewers (Anon, 2003)

	ICG				
% by length	1	2	3	4	5
	55	12	16	15	2

Note: Internal Condition Grade (ICG) 1: Acceptable condition
ICG2: Short-term risk of collapse is minimal
ICG3: Collapse unlikely in near future, but likely to deteriorate
ICG4: Collapse likely in foreseeable future
ICG5: Collapse imminent/collapsed

Table 1.11. Reasons for private sewer faults (Anon, 2003)

Problem Type	Number of incidents per annum
Ownership disputes	45,000
Flooding due to public sewer surcharging	42,000
Flooding due to structurally defective private sewers	46,000
Flooding due to hydraulically defective private sewers	20,000
Failure of pitch fibre pipes	50,000
Lateral drains	58,000

In order to minimise risk to rural areas, a rationalisation of the private sewer system in necessary, with particular attention paid to ownership disputes with the aim of reducing neglect and mismanagement. Private sewers are not inherently dangerous to the surrounding environment, but stringent management and monitoring is required to maintain quality of the network.

1.3 History of UK STW

UK wastewater has been subject to a degree of processing for approximately 1400 years (Cooper, 2001). Early roman settlers constructed wood-lined sewers (later surpassed by brick-lined sewers) in approximately 400AD beneath the streets of London. However, these systems were soon abandoned around 450AD when the Roman Empire disintegrated. Until 1189, when there is documentary evidence of cesspools in London, it is thought that little provision for domestic waste processing was made.

During the industrial revolution sewage from urbanised areas was often collected in cesspools, and subsequently sold to rural farmers for land application as fertiliser (Cooper, 2001). Expanding urban populations during the industrial revolution (c1750-1950) provided a much-needed catalyst for improvements to sewerage systems. Sir Edwin Chadwick (1800-1890), an influential figure in the 1800's, produced a landmark report regarding the sanitary conditions of the British working class, leading to the establishment of the 1848 Public Health Act that created local boards of health with the power to construct sewers. This power drastically reduced the number of cesspools required, consequently reducing the prevalence of numerous waterborne diseases (Cooper, 2001).

From 1858-1865, Sir Joseph Bazalgette constructed the UK's first major sewer system in London. Contrary to previous disposal techniques, sewage was discharged into the River Thames rather than export to the surrounding countryside. The Public Health Act of 1875 enforced the requirement for Local Authorities to construct drainage and sewerage systems in all areas and included sections on water pollution and sanitation. By 1944, almost 100% of urban households had access to mains sewerage and potable water, whereas rural access was approximately 70% (Anon, 2006). To increase the proportion of mains connected rural households, the 1944 Rural Water Supplies and Sewerage Act was produced, giving financial support to rural connection projects. The act allowed the government to award up to £15 million to rural connection projects in England (£6,375,000 in Scotland). Although rural connection projects financed by the act were hindered by lack of labour and materials, by March 1950 £9,839,000 had been awarded in England and Wales, whilst £6,619,000 had been awarded in Scotland (Defra website 2007). This act resulted in increasing the number of rural households connected to the mains supply and reducing amount of raw sewage discharged into the environment (Defra website 2007).

2.0 Administrative structure and legislation

2.1 Administrative structure

The administrative structure of the UK wastewater industry (figure 2.1) is a mixture of public and private institutions, headed by the European Union and the Government Department for Environment Food and Rural Affairs (Defra).

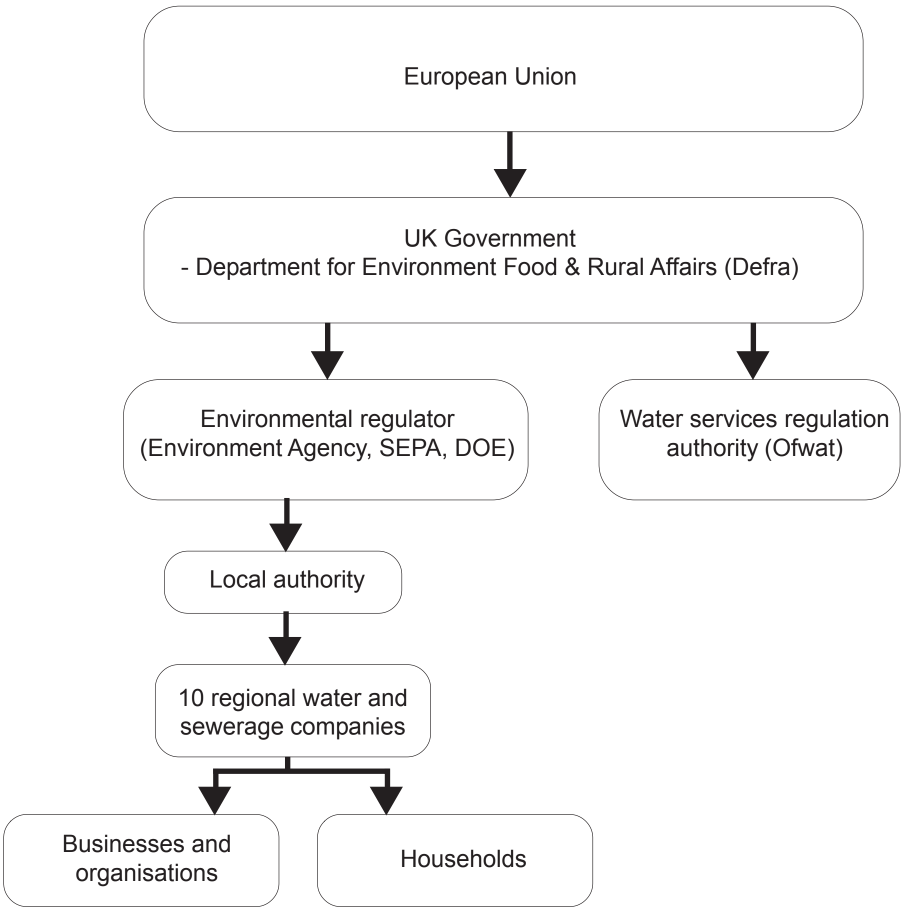


Figure 2.1. UK wastewater administrative structure

European Union: An intergovernmental union of 27 nation states established by the Maastricht Treaty of 1992, the EU is responsible for the production of directives regarding environmental standards. Notable legislation includes the Water Framework Directive (WFD; 2000/60/EC) introduced in 2000 that aims to improve both the ecological and chemical waterbodies of all EU waterbodies and the UWWTD (see section 5).

Department for Environment, Food and Rural Affairs (Defra): Defra is a government department formed in 2001 by the merger of the Ministry of Agriculture, Fisheries and Food, and the Department of Environment, Transport and the Regions. Defra produces policy frameworks for England and Wales and is responsible for the protection of the environment, rural communities, fisheries, agriculture and food production standards. Defra is also responsible for transposition of EU directives into UK law, drafting legislation (to be passed by Parliament) and setting of standards. Defra is headed by the Secretary of State who has ultimate responsibility.

Environmental regulator: The environmental regulator is the principal advisor to the government and is responsible for enforcing environmental law, granting consents and protecting the natural environment. Income is generated from three sources:

> **i) Monies raised from various charging schemes**
> Charges are levied on water abstraction licences, industrial and business matters, fishing licences and waste management licences;
>
> **ii) Flood defence levies**
> These are provided by the Local Authority to fund flood defence programmes and associated activities within their district;
>
> **iii) Grants from government**
> Defra and the National Assembly of Wales provide around 25% of the required annual budget to England and Wales respectively (EA website, 2007).

The environmental regulator controls and monitors industrial and municipal effluent discharges using three assessment mechanisms:

> i) Relevant EU directives and subsequent UK Surface Water Regulations (1994);

ii) UK statutory water quality objectives set by the environmental regulator;

iii) The 1991 Water Resources Act.

In England the environmental regulator is the Environment Agency, whilst in Scotland and Northern Ireland the Scottish Environmental Protection Agency (SEPA) and Department of Environment carry fulfil this function respectively. The Environment Agency and SEPA were created by the Environment Act of 1995, and were charged with taking over the responsibilities of the National Rivers Authority and Her Majesty's Inspectorate of Pollution and all waste regulations from Local Authorities.

The Water Services Regulation Authority (Ofwat): Ofwat is the independent organisation created in 1989, responsible for the economic regulation of the English and Welsh water industries; the Scottish water industry regulator is the Water Industry Commission for Scotland. Ofwat has the power to limit prices charged for services by the water and sewerage companies and produces regular reports regarding state of the water industry.

Local Authority: The organisation of UK Local Authorities are a result of numerous reforms, with powers and titles varying throughout the UK. Within England there are unitary authorities (responsible for all local government functions), metropolitan districts (covering large urbanised areas) and a variety of county, district and city councils. Local Authorities control planning applications and other building regulations including those relating to sewage treatment.

Regional water and sewerage companies: Ten water and sewage companies were created when the industry was privatised in 1989 and are responsible for the removal of sewage from the majority of English and Welsh households connected to the mains network. They are also responsible for the maintenance and construction of the sewage network.

Businesses and organisations: User of water services

Individuals: User of water services

2.2 Essential national legislation

The majority of UK legislation regarding sewage treatment is derived from interpretation of relevant EU directives. All discharges to controlled waters are facilitated through regulatory frameworks and the most prominent pieces of UK legislation are the Water Resources Act (1991) and the Environment Act (1995). Both of the aforementioned pieces of legislation fulfil a number of functions including:

– definition of which waters are to be controlled;

– classification of controlled waterbodies;

– provision of a framework for the establishment of statutory water quality objectives aimed at improving and maintaining water quality;

– identification of nitrate sensitive areas and water protection zones;

– granting powers of discharge control and recovery of costs to environmental regulator.

All wastewater released into controlled waters is required to be treated to some degree. Organisations or individuals proposing to discharge effluent to controlled waters must apply to the environmental regulator for consent, the outcome of which will be refused if projected impacts are environmentally unacceptable. There are currently 3 types of consent currently granted in the UK:

– Descriptive
Defines type of effluent treatment and requires it to function within accepted standards of good practice. Usually only applied to small STW (<250 p.e.);

– Numerical
Introduces concentration limits of specified determinands within effluents. Common parameters include Biochemical Oxygen Demand and Suspended Solids;

– Non-numeric:
Limited to discharges where no numerical consent is possible i.e. sewer overflows.

If a new STW or other piece of sewage processing apparatus is to be constructed it must comply with statutory requirements and building regulations (in accordance with the relevant British Standard). The most relevant standards and requirements are:

- **BS 6297** (1983): *Code of Practice for Design and Installation of small sewage treatment works and cesspools.* Suitable for <100 p.e;

- **BS 7781** (1994); *Procedure for type testing of small biological domestic wastewater treatment plants.* Suitable for <50 p.e;

- **BSEN** 12566-3; *Small wastewater treatment systems.* Suitable for <50 p.e.

- **CE marking**; guarantees that products comply with EU health, safety and environmental legislation (Product Directives);

- **Agrément certificates**: issued by the British Board of Agrément (BBA), confirming that product conforms to UK Building Regulations.

3.0 Planning and implementation procedures

3.1 Selection of appropriate system

When proposing new sewage management systems it is advisable to characterise the nature of waste requiring treatment. Process options will vary greatly depending on the typical composition of influent. When initiating a new sewage management strategy, a robust plan should be adhered to, ensuring legal compliance and suitability (an example of a common project management procedure is shown in figure 3.1). Close consultation with the environmental regulator, the Local Authority, environmental engineers and building contractors is advised to accurately assess process requirements and ensure compliance with legal and environmental legislation.

System selection is dependant on a number of factors, notably feasibility in financial, temporal and practical terms. A methodology for choosing process configurations is shown in figure 3.2.

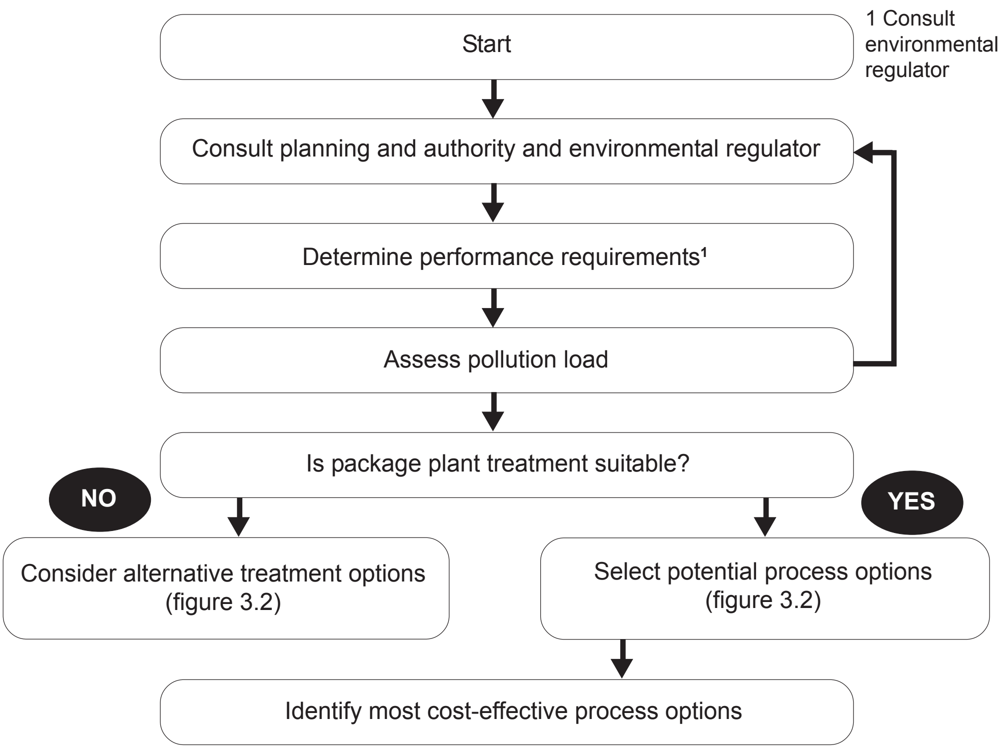


Figure 3.1. Plant selection procedure (adapted from Dee and Sivil, 2001)

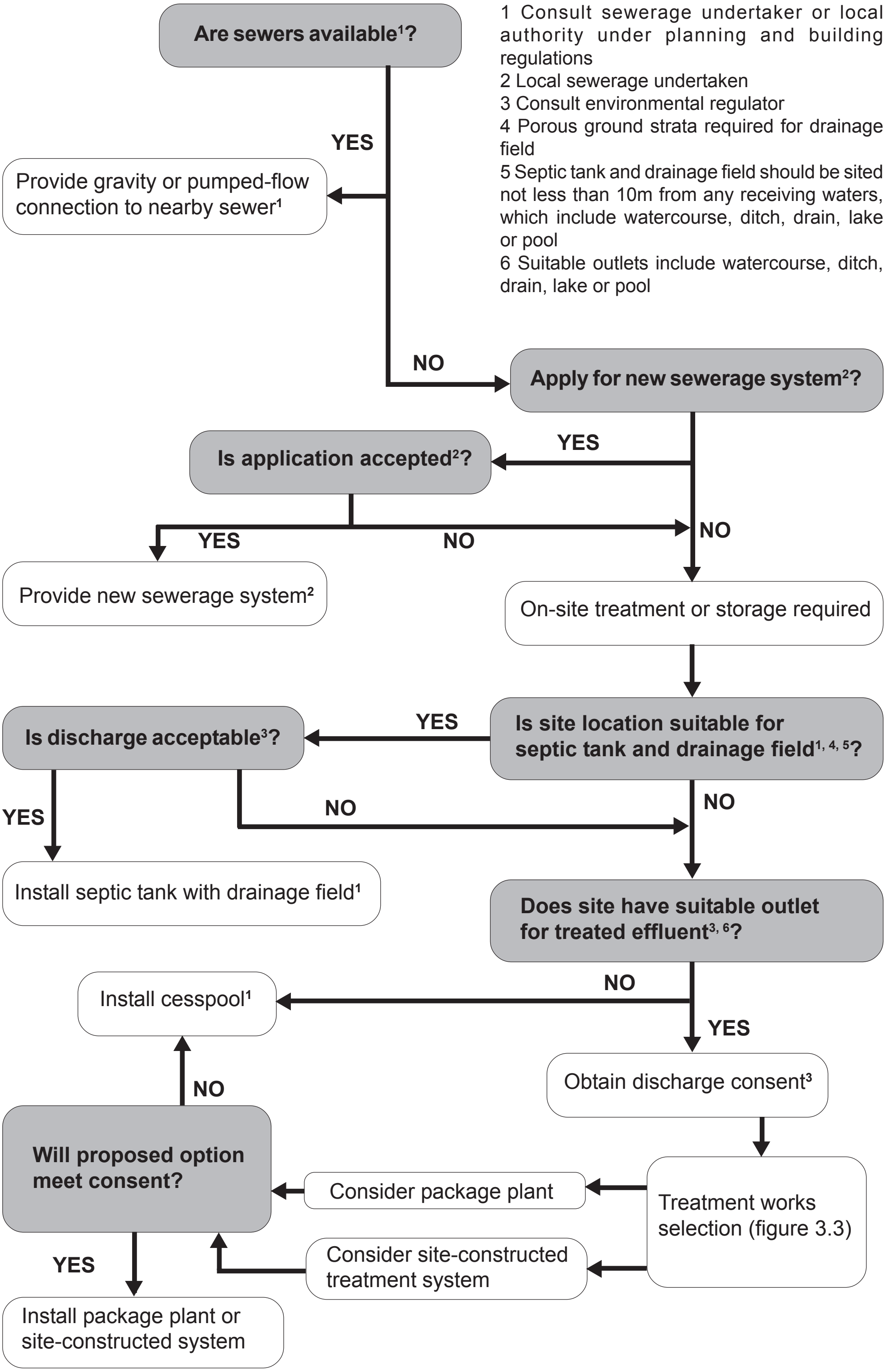


Figure 3.2. System selector chart (adapted from Dee and Sivil, 2001)

Table 3.1. Comparison of wastewater treatment systems (adapted from Dee and Sivil, 2001)

	Cesspool	Septic tank and drainage field	Package plant	Reedbed following pre-treatment
Discharge to watercourse	Not permitted	Not applicable	Yes	Yes
Consent requirement[A]	Not applicable	Yes	Yes	Yes
Closeness to dwelling	>15m[E]	>15m[C, E]	>5m	>25m[D, E]
Closeness to Watercourse	>10m	>10m	>10m	>10m
Closeness to well or borehole	Not applicable	Should not be in vicinity-distance depends on site	-	-
Power supply	No	No	Yes	Possible[B]
De-sludging or emptying	Up to 12 times per year	Once per year	2-6 times per year	Replacement of gravel (every 20 years)
Maintenance	No	Minimal	Yes -regular	Minimal

A Consent is required from regulator for any discharge of sewage effluent into controlled waters. May also be required for discharge to land
B Vertical flow reedbeds normally require a pumped flow whilst horizontal reed beds do not
C Drainage field should be located on land sloping away from property
D Needs to be adequately fenced
E BS 6297 (1983)

Protection of public health and chemical/ecological quality of water supplies should of paramount importance when selecting site and type of treatment system to be used. Table 3.1 illustrates factors to consider when choosing sewage processing options and system suitability will vary from site to site. When evaluating treatment options for small/rural communities, a procedure similar to that shown in figure 3.3 could be followed. Accurate estimation of influent loads and flows, and final effluent requirements is essential, further details of which can be found in BS6297.

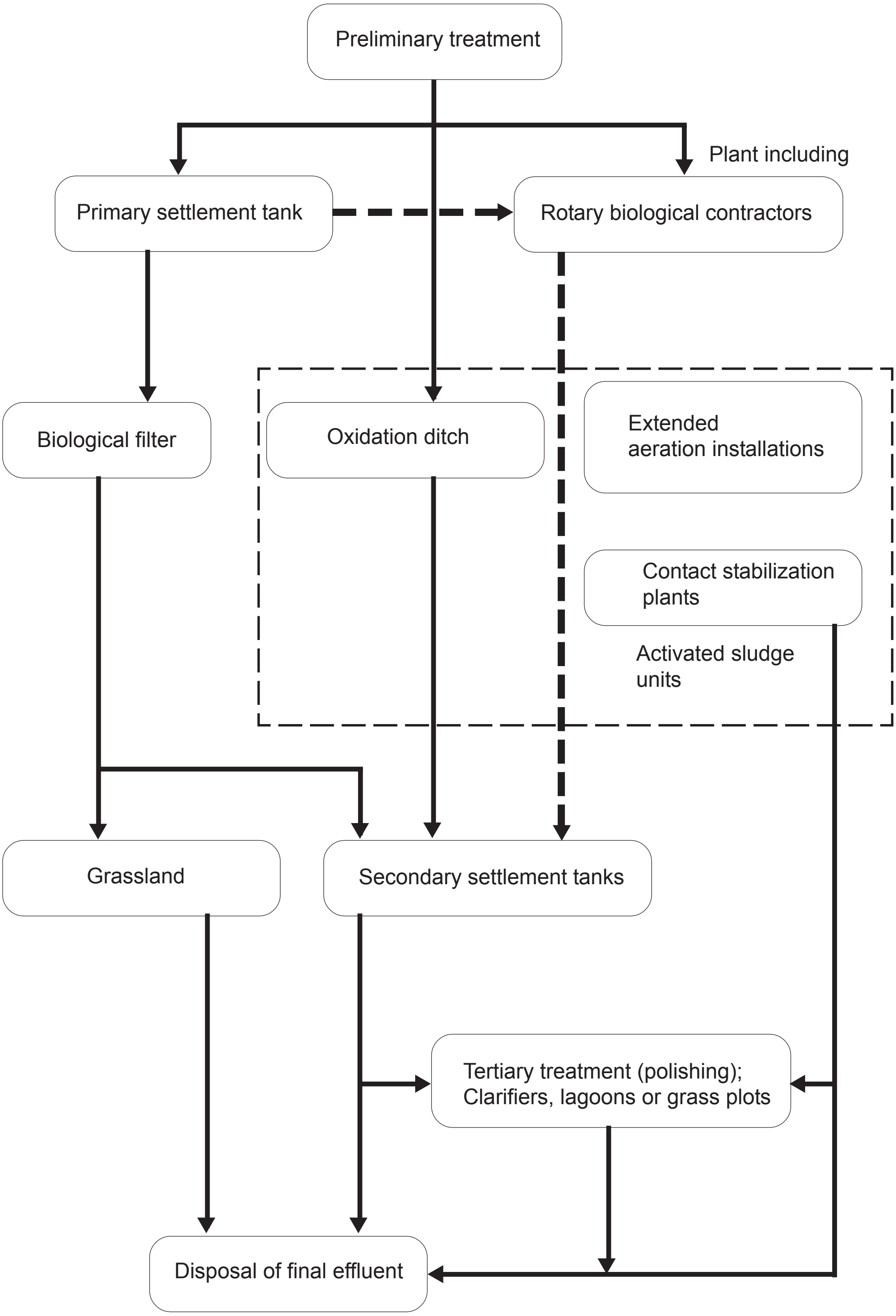


Figure 3.3. Sewage treatment: broad options for small communities (adapted from BS6297)

4.0 National special expertise

As has been outlined the majority of UK households are connected to the mains sewerage network, thus there is little scope, or indeed need, to developed special expertise for rural sewage treatment processing. However, one area where the UK has been active is the development of sewage treatment reed beds. The aim of this section is to give a brief introduction to theory and give examples from the UK.

4.1 Types and extent of UK reed bed systems

Two types of reed bed are predominantly used in the UK:

– Vertical flow, or downflow, systems (VFS);

– Horizontal flow systems (HFS).

Although using 'natural' treatment systems such as wetlands has been practised for hundreds of years, it was not until the mid 1980's that the concept was given serious thought by environmental managers and engineers (Grant and Griggs, 2001). In 1985, the Water Research Centre (WRC) undertook research into SFS, whilst numerous independent companies were researching VFS. Recognising these activities, the International Conference on Constructed Wetlands was held in Cambridge in September 1990. Estimations put the number of reed bed systems used by water companies at around 530 in 2000 (Grant and Griggs, 2001). The number of privately owned systems is currently unknown.

4.1.1 Vertical flow systems

VFS employ alternating sand and gravel layers through which wastewater drains under gravity. It is usual for a number of beds to be constructed, allowing the withdrawal of one for cleaning and recovery. It is common for two or more VFS to be used in series, in combination with secondary settlement tanks, or in combination with horizontal flow reed beds. In the UK the predominant arrangement is vertical flow followed by horizontal flow (Grant and Griggs, 2001) and it is unusual to see VFS used alone. Choice of operating procedure is dependant on a number of factors and some general considerations are shown in table 4.1.

Table 4.1. Advantages and disadvantages of vertical flow reed beds (adapted from Grant and Griggs, 2001)

Advantages	Disadvantages
High levels of treatment possible (<20mg/l BOD and suspended solids	Requires a vertical fall of around 1m
Good nitrification	Intolerant of hydraulic overloads
Low area requirement (1-3m^2/p.e.)	Sand or soil specification is critical
Blockage likely to be in the surface layer	Construction has to be meticulously planned
Tolerant of solids in the wastewater	Requires regular maintenance, typically weekly inspection and alternation of beds
Aerobic effluent	Localised odour caused by wastewater on the surface of first stage Unlike HFS, VFS cannot be flooded for weed control May require secondary (humus tank) settlement

Performance of VFS tends to be better in summer due to increased biological and chemical reaction rates (Grant and Griggs, 2001) but good design can mitigate this seasonality. Further details of appropriate design can be found in Grant and Griggs 2001)

4.1.2 Horizontal flow systems

There are three types of HFS currently in use in the UK:

– **Subsurface flow systems (SFS)**
Wastewater is passed through planting media (sand, soil or gravel) and the root zone; this method is also known as the root zone method and is suitable for secondary treatment. Water levels should be kept to within 25-500mm of ground surface, and systems should have the capacity to flood as this aids weeding. The advantages and disadvantages of SFS are shown in table 4.2;

– Horizontal flow systems for tertiary treatment

Where a high quality effluent is required, HFS can polish effluent removing significant nutrient loads, producing an effluent of reduced strength. This process is becoming increasingly common in the UK and features in many STW upgrades. The advantages and disadvantages of HFS for tertiary treatment are shown in table 4.3;

– Free water surface systems (FWS)

These systems are rare in the UK, and rely on overland flow.

Table 4.2. Advantages and disadvantages of SFS reed beds for biological treatment

Advantages	Disadvantages
Simple construction Minimal fall required Tolerant of hydraulic overload Requires little maintenance Weed control possible by surface flooding Easily fitted into landscape Good pathogen removal	Minimal nitrification (ammonia removal) Anaerobic effluent Odour may be an issue Solids in wastewater can cause premature blockage Larger area requirement than VFS (5-10 m2/p.e.)

Table 4.3. Advantages and disadvantages of HFS reed beds for tertiary treatment

Advantages	Disadvantages
Simple construction Minimal fall required (<200mm) Tolerant of hydraulic overload Requires little maintenance once established Weed control possible by surface flooding Low cost Can provide stormwater treatment Robust Good buffering of peak flows Can provide denitrification of nitrified effluent Proven performance	Minimal nitrification Solids in wastewater can cause premature blockage Minimal long-term phosphorus removal

HFS (inc. SFS) appear to work best when wastewater is slightly diluted and in such situations BOD removal can be very high (Grant and Griggs, 2001).

4.2 Case study

To give an indication of typical reed bed system performance an example from the UK is given in the following sub-section.

4.2.1 Slimbridge Wildfowl and Wetlands Trust

The goal of this programme was twofold, to treat effluent from the visitor centre on-site and to create sustainable wildlife habitats for a range of species. When designing the treatment system, a number of key criteria had to be fulfilled:

– To treat wastewater from visitor centre, with a daily turnover of 0 - 6,000 and significant seasonal variation. Also to treat household effluent from 2 residential families and 100 non-residential staff;

– All solids and sludge had to be treated on site;

– Meet a discharge consent of 25:45 (BOD:SS);

– Create 2500m^2 of viable wildlife habitat;

– Low concentrations of N and P in final effluent;

– Easy access for maintenance vehicles;

– To blend in with existing environment;

– To use minimal fossil fuels during operation

– Be designed and built for less than £110,000.

A multi-stage system was chosen incorporating VFS, SFS and FWS, a schematic diagram of this system is shown in figure 4.1. The VFS achieves the BOD and SS limits imposed by the EA, whilst N and P removal occurs in the subsequent stages.

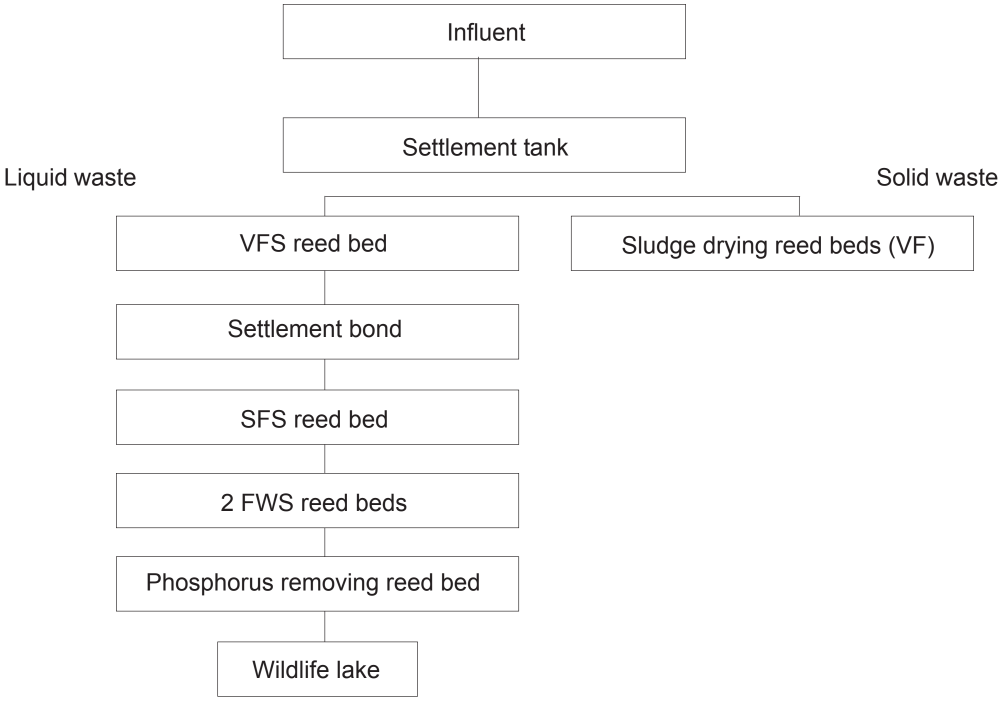


Figure 4.1. Schematic diagram showing Slimbridge reed bed treatment system

The settlement tank (8m diameter, 2m working depth) was designed to process 80-120m^2 of influent per day, with rotary scrapers removing both surface and settled solids every 24 hours into one of a pair of vertical flow (VF) sludge drying beds (50m^2, 1m deep). These beds are operated on a 6-month on/6-month off basis. Liquid effluent is then transported over a V-notch weir and pumped into the VFS reed bed. The VFS reed bed (400m^2, 0.9m deep) is comprised of gritty sand (700mm deep) on top of 10mm clean stones for blinding (50mm deep) and 500mm clean stones for drainage (150mm deep). The bed allowed 1m^2/p.e. for 1500 visitors per day. The reed used was entirely Phragmites australis. The VFS stage of the treatment process is fundamental in reducing BOD and SS to levels below levels set by the EA. Nitrification is encouraged during the VFS stage by using a calcerous substrate, this also increases redox potential and higher than normal pH that binds phosphate.

The SFS reed bed (150m^2, 0.5m deep) receives discharge from a small settlement pond (50m^2, 1.5m deep), which is designed to decrease the redox and increase the pH, both of which aid denitrification during the SFS stage. A siliceous gravel mix is used in the SFS bed to maintain both low redox and pH values. The dual FWS reed beds are planted with Phragmites and offers habitat similar to natural reeds, encouraging reed warblers. Algal photosynthesis and shallow water allow reoxygenation of the effluent, and removal of BOD and SS creating optimal conditions for the phosphate removal bed (100m^2, 1m deep). An aluminium-rich clay matrix (Alphagrog) is used in the phosphate removal bed, arranged in layers of 2mm, 5mm, 20mm and 50mm. Phosphate adsorption is maximised by increasing both pH and redox values. The effluent is discharged via an unlined clay wildlife pond, before it is discharged to the River Severn via a large ditch. Performance of the system is characterised by high SS and BOD removal, but denitrification is limited, this is shown in table 4.4.

Table 4.4. Slimbridge reed bed wastewater treatment system chemical analysis (averaged samples from June 1999 to February 2000 (adapted from Grant and Griggs, 2001)

Stage	BOD	TSS	NH_3 - N	TON	oPO_4 - P	pH
Settlement tank	93	60	31.72	0.1	5.25	7.7
Settlement pond	1.35	8	4.77	13.57	2.07	7.5
SFS out	2	8.33	2.55	30.73	1.37	7.83
FWS out	<2	6	<0.5	30.3	2.1	7.4
Final effluent	1.5	7	0.14	32.8	0.34	7.9

NB: All units in mg/l except pH
NH3 - N = ammoniacal nitrogen; TON = total oxidised nitrogen; oPO4-P = orthophosphate phosphorus

5.0 Nutrient stripping in the UK

Nutrient stripping, or tertiary nutrient removal, is the final stage of sewage treatment and where employed correctly, is capable of producing an effluent of the highest quality (i.e. <1 mg-P l-1). As freshwater eutrophication is of concern in the UK, the majority of nutrient stripping activities have been directed at reducing P concentrations in STW effluents (P is often the critical factor controlling riverine eutrophication). This chapter presents the results of an investigation undertaken by the University of Brighton into the scope and methods of phosphorus stripping at UK STW. Nitrogen stripping is also briefly discussed at the rear of the section. The companion Lakepromo Pilot Area Report will give details of a case study documenting the effects and environmental impacts of nutrient stripping at 2 STW that discharge into the Pevensey Levels.

5.1 Drivers behind introduction of tertiary treatment systems at UK STW

There are no specific government orchestrated programmes aimed at introducing P removal at UK STW. The primary drivers underlying improvements to UK wastewater processing are regulations prescribed in EU Directives and their subsequent transposition into UK law, the most significant of which, the Urban Waste Water Treatment Directive (UWWTD), was adopted by the UK in 1994. The UWWTD made it mandatory to introduce secondary biological treatment at STW >10,000 p.e, and tertiary nutrient removal at STW >10,000 p.e. discharging into notified ecologically Sensitive Areas (SA). Before introduction of the UWWTD, nutrient removal by tertiary treatment in the UK was rare, notable exceptions being STW that discharged into Lough Neagh (Northern Ireland), which had P removal installed in the 1970s.

Identification of SA status, as defined in the UWWTD, is founded upon three criteria:

i) where a water body is eutrophic, or at significant risk of eutrophication;

ii) where a water body exceeds, or potentially exceeds, specified nitrate concentrations potentially affecting water supply sources;

iii) where discharges affecting a water body are subject to more stringent treatments in order to comply with standards imposed by other directives.

SA designated under criteria 1 and 2, require additional N or P removal at all STW >10,000 p.e., unless removal of nutrients would have no effect on levels of eutrophication (Kelly and Wilson, 2004). Upon designation, the relevant water service companies have 7 years in which to upgrade affected STW to the required standard; as P is generally the limiting nutrient within freshwater systems, this is where efforts have been concentrated within the UK (Mainstone and Parr, 2002). In the first round of SA identification, 37 sites were identified as requiring P stripping, accounting for approximately 5.2% of total UK STW effluent (IEEP 1999, in Mainstone and Parr, 2002). Furthermore it is also believed that the UK could do more to reduce P concentrations in STW with tertiary treatment already installed (Anon, 2004).

Table 5.1. Sensitive Area types and designation dates up to 2003 (Defra, 2006)

Criteria	England	Wales	TOTAL
Eutrophic (1)	112	5	117
Nitrate (2)	8	0	8
Bathing Water (3)	180	9	189
Shellfish (3)	47	1	48
TOTAL	**347**	**15**	**362**

Review of UK SA's is undertaken by the EA every four years, identifying new SA's and confirming existing ones. As of 2003, there were 362 SA identified in England and Wales, 117 of which are classified as being, or at significant risk of becoming, eutrophic. Only 8 are designated as being sensitive to nitrogen (table 5.1 and Appendix II). The EU believes that many more SA in the UK should be designated in the next round (Anon, 2004).

As previously alluded to, the other drivers behind process improvements within the UK include:

– Habitats Directive (92/43/EEC);

– Bathing Water Directive (76/160/EEC);

– Shellfish Waters (79/923/EEC);

– Groundwater Directive (80/68/EEC);

– Surface Water Abstraction Directive (75/440/EEC);

– Natural England (Government organisation) administered Site of Special Scientific Interest (SSSI) regulations;

– Environment Agency orchestrated River /Estuarine Quality objectives.

5.2 UK transposition of the UWWTD

The UK interpretation of the UWWTD is significantly different from other EU member states, therefore the extent of P stripping required by UK law correspondingly differs. Whereas the UK undertakes a system of SA adoption, with the total number tending to increase as a result of periodic review every four years, other Member States (e.g. Belgium and Sweden) have designated their entire territories as being SA whilst other EU member states have designated vast majorities of their territory as being SA (France and Germany). As of 1999, Germany had 900 STW with P stripping installed, whereas by 1997, the UK had just 23 (IEEP 1999, in Mainstone and Parr, 2002). In conjunction with the amount of territory identified as SA, many countries, including the Netherlands, Denmark, Luxembourg, Finland, Austria and Germany, impose stricter controls and limits than required by the directive. As the UK water industry is privately owned, therefore profit driven, it may not be economically prudent to do more than is legally required.

As January 2002, 71% of STW load to UK SA was not meeting the P stripping requirements (table 5.2). This is in stark contrast to other member states such as Denmark (96% compliance), Italy (72%), Austria (100%) and Sweden (73%). Of the 90 agglomerations >10,000 p.e. designated as discharging into SA in 1994, the UK authorities consider that 88 (98%) provide the required levels of treatment, but this figure is disputed by the EU (Anon, 2004) it puts compliance at 22 out of 90 (24%).

A fundamental difference in UK interpretation of the UWWTD is that SA hydrological catchments are considered insignificant, therefore STW in SA catchments are not required to perform P removal. This is not a view shared by the EU commission, and it believes that there are a significant number of affected waterbodies that have not yet been notified as SA. Non-designation represents an infringement of the UWWTD and is currently under investigation (Anon, 2004). At the beginning of 2001, 90% of the UK's Water service companies were compliant with the UWWTD requirement of installation of secondary treatment at STW >10,000 p.e. (Defra, 2006) and by end of 2002, it was expected compliance would be 98% (Defra, 2006), however the current figure is unavailable.

Table 5.2. Member states UWWTD SA compliance up to January 2002 (Anon, 2004)

Member State	Agglomeration Concerned Number	Load (tonnes)	Complying Number	Load	%	Not Complying Number	Load	%
Belgium	186	8,952,516	72	2,566,050	29	114	6,386,466	71
Denmark	127	6,698,384	122	6,429,418	96	5	268,966	4
Germany	3859	124,876,488	n/a	n/a		n/a	n/a	
Greece	17	609,400	8	241,400	40	9	368,000	60
Spain	113	5,740,260	34	1,407,984	25	79	4,332,276	75
France	348	16,728,379	43	6,086,935	36	205	10,641,444	64
Ireland	28	3,362,856	12	269,478	8	16	3,093,378	92
Italy	49	3,024,094	28	2,165,493	72	16	661,748	22
Luxembourg	11	804,500	3	108,500	13	8	696,000	87
Netherlands	394	15,906,991	n/a	n/a		n/a	n/a	
Austria	25	1,851,885	25	1,851,885	100	0	0	0
Portugal	27	1,372,700	589	148,500	11	22	1,224,200	89
Finland	87	6,377,300	7	429,600	7	80	5,947,700	93
Sweden	134	7,672,670	74	5,629,760	73	60	2,042,910	27
UK	90	6,221,177	26	1,782,241	29	64	4,438,936	71

Note: Germany and the Netherlands are excluded as they do not measure STW conformity, but consider a % reduction of N and P load for whole territory.

5.3 Methods of phosphorus removal in the UK

As previously stated, STW >10,000 p.e. discharging into notified SA are required under the UWWTD to perform tertiary P removal. In the UK, there are two methods of tertiary P removal commonly used:

i) chemical precipitation;

ii) Biological Nutrient Removal (BNR).

The advantages/disadvantages of P removal by chemical precipitation and BNR are shown in table 5.3.

Table 5.3. Advantages and disadvantages of chemical and biological P removal

Advantages	Disadvantages
Chemical ~ Reliable, well understood technique ~ Chemical costs can be reduced if pickle liquors are used (ferric chloride/sulphate) ~ High degree of control ~ Easy/inexpensive to install ~ Sludge can be processed in the same manner as non P removal systems ~ 25-35% reduction in organics load to secondary unit if metal addition is in primary clarifier	**Chemical** ~ High sludge production ~ High chemical costs ~ Sludge produced is harder to de-water ~ Tertiary filtration is required to facilitate P in suspended solids ~ Iron may colour effluents ~ Inefficient process may lead to toxicity ~ 25-35% reduction in organics load to secondary unit if metal addition is in primary clarifier
Biological ~ Similar volumes of sludge to conventional activated sludge system ~ Easily installed at plug flow reactors ~ Minimal/no chemical costs ~ N removal may be simultaneously performed ~ Provides greater control over filamentous organisms	**Biological** ~ Controlled by BOD:P ratio in wastewater ~ Highly efficient secondary clarifier performance is prerequisite ~ Existing fixed film systems not easily converted ~ Possible P release in sludge processing ~ Chemical backup required in case of system failure ~ Poor settling sludge ~ Increased retention times are required

Source: Adapted from Mainstone and Parr 2002.

As water service companies are profit driven (Ogden and Anderson, 1999), financial costs are of paramount concern and particularly important when selecting P removal process options. Certain technologies, such as BNR, require preceding activated sludge systems that are usually exclusively installed at larger STW due to high capital costs. At smaller STW, fixed film biological treatments are commonplace thus only chemical nutrient removal is feasible. As the majority of UK STW are small (approximately 1600 STW have p.e.>2000; 700 serve p.e.>10,000; EA website, 2007) the predominant mechanism of P removal at UK STW is chemical precipitation. There are a number of Thames Water STW that utilise BNR (the 3 stage Bardenpho, or the Sebokeng configurations), but these are isolated examples and a degree of chemical nutrient removal by iron addition is used in support.

Phosphorus removal by chemical precipitation was first used at UK STW within the Lough Neagh catchment (Northern Ireland) during the 1970's but was not widely adopted until transposition of the UWWTD during the 1990's. Since transposition of the UWWTD, the number of SA has increased steadily, thus the number of STW required to perform nutrient removal is projected to increase correspondingly. Effluent polishing, or contact filtration, may also be employed at STW to further enhance P removal and the proliferation of these techniques is currently unknown.

5.3.1 Chemical precipitation

Agents utilised in the chemical precipitation process are metal salts including iron (Fe^{2+} or Fe^{3+}; both the sulphate and chloride salts of Fe^{2+} and Fe^{3+} can be used), calcium (Ca^{2+}) and aluminium [$Al_2 (SO_4)$ or $Na_2Al_2O_4$]. When the chosen metal salt combines with dissolved forms of P present in wastewater, sparingly soluble salts are formed (table 5.4), and flocculation/coagulation of suspended solids is enhanced (Droste, 1997).

Table 5.4. Precipitates formed during phosphate precipitation (adapted from Sedlak, 1991)

Phosphate precipitant	Precipitates that may form
Ca (II)	Various calcium phosphates e.g. o ß - tricalcium phosphate: $Ca_3(PO_4)_2(s)$ o hydroxyapatite: $Ca_5(OH)(PO_4)_3(s)$ o dicalcium phosphate: $CaHPO_4(s)$ calcium carbonate: $CaCO_3(s)$
Fe (II)	ferrous phosphate: $Fe_3(PO_4)_2(s)$ ferric phosphate: $Fe_x(OH)_y(PO_4)_3(s)$[a] ferrous hydroxide: $Fe(OH)_2(s)$ ferric hydroxide: $Fe(OH)_3(s)$[a]
Fe (III)	ferric phosphate: $Fe_x(OH)_y(PO_4)_z(s)$ ferric hydroxide: $Fe(OH)_3(s)$[a]
Al (III)	aluminium phosphate: $Al_x(OH)_y(PO_4)_3(s)$ aluminium hydroxide: $Al(OH)_3(s)$

The P enriched solids can then be re-processed for disposal. Examples of process equations are given below:

– Ferric ion reaction is illustrated by:

$$\mathbf{Fe_3 + + PO_4^{3-} \rightarrow FePO_4 \downarrow}$$

– Aluminium ions reaction is illustrated by:

$$\mathbf{Al_3 + + PO_4^{3-} \rightarrow AlPO_4 \downarrow}$$

By far the most common metal salt used at UK STW is iron (particularly ferric sulphate), with only a number of plants using aluminium salts (2 Thames Water STW and 2 Dwr Cymru STW). It has been speculated that as iron becomes increasingly expensive, aluminium usage may become increasingly common (Reeves, pers comm.). When selecting the metal salt to be used, a number of criteria should be used. These include:

– Cost;

– Alkalinity consumption;

– Quantities of sludge generated;

– Safety.

Ultimate selection of chemical used should be made in accordance with consultations with environmental regulators and chemical engineers.

5.3.1.1 Point of dosing

Dosing methods of the individual Water service companies are not available for analysis, but it is known that the use of online monitors in the UK has proved unreliable (this was experienced at Southern Water and Northumbrian Water STW); over/under dosing was common, thus P removal was often inefficient. It is common UK practice to estimate amount of metal salt to be added by using as dosing profile. The constructed profile is formulated from a number of samples taken over 24 hours, from which a diurnal P profile is derived. The amount of metal salt required to precipitate P present is then calculated and metal salt addition adjusted accordingly throughout the day. There are a number of dosing configurations used when adding metal salts to STW liquor:

– Direct Precipitation: agent is added to wastewater before the primary settling tank. Fe^{2+} salts may be unsuitable for this process;

– Pre-precipitation: agent is added to wastewater, then rapidly mixed, followed by flocculation and primary settling;

– Simultaneous Precipitation: agents are added directly to aeration basin, or at the inlet;

– Post precipitation: agents are added after secondary settling.

Some common problems and issues are given in table 5.5.

Table 5.5. Dosing point issues (adapted from Sedlak, 1991)

Dose point	Anticipated P in effluent (mg/l)	Issues
Primary treatment	>1	Enhances BOD and TSS removal efficiency Efficient chemical usage Reduces phosphate loading in subsequent stages May require polymer flocculation
Secondary treatment	>1	Less efficient chemical use Additional inert solids Phosphate carryover in effluent TSS
Primary and secondary treatment	1 to 0.5	Slightly increased cost
Tertiary treatment	<0.5	Significantly increased cost Should be used where strict standards are imposed.

From consultation with various representatives from the water and sewerage companies, it appears that dosing during the tertiary treatment phase is prevalent in the UK. This is necessary to reach the required effluent standard (see sub-section 5.6) imposed by the environmental regulator. Choice of dosing point is based on site conditions, wastewater strength, required final effluent P concentration and metal salt used in chemical precipitation process.

5.3.2 Biological nutrient removal

Biological nutrient removal involves bacterial polyphosphate accumulating organisms that are enriched and accumulate P within their cells, a process known as enhanced biological phosphorus removal. It is possible to harvest these bacteria, which can then be sold as fertiliser. BNR will not be discussed in detail in this report, details of design and processes can be found in Sedlak (1991).

5.4 Extent of P stripping in the UK

Table 5.6 shows the extent of nutrient stripping currently carried out in the UK during asset management planning (AMP) period 3 that ran from 2000-2005.

Table 5.6. Extent of nutrient stripping in the UK and primary drivers until 2005

Company	STW	No with P removal	%	SSSI Only	Habitats Directive Only	UWWTD	Other	No with N removal
Anglian	717	44	6.1	1	5	38	0	0
Dwr Cymru	614	8	1.3	0	4	4	0	2
Northumbrian	64	10	6.1	0	2	10	0	0
North West	?	11	n/a	0	2	6	3	0
Severn Trent	723	39	5.4	7	0	32	0	n/a
Southern	285	16	5.6	13	0	3	0	0
South West	319	2	0.6	0	0	2	0	n/a
Thames	352	49	13.9	7	0	42	0	0
Wessex	288	21	7.3	0	4	16	1	0
Yorkshire	301	11	3.7	n/a	n/a	n/a	n/a	0

There are 211 STW in England and Wales which performing tertiary P removal, this represents 5.3% of all STW (excluding North West Water for which data was unavailable), the significant majority of which utilise chemical precipitation by addition of iron salts. The predominant driver behind process installation is the UWWTD directive, table 5.7, approximately 75.7% of P stripping schemes (excluding Yorkshire Water as drivers are unknown) are a result of directive prescriptions (i.e. STW >10,000 p.e. discharging into SA). A further 13.9% of P stripping initiatives were required solely due factors resulting in SSSI designation, whereas 8.4% were installed due to requirements of the Habitats Directive (92/43/EEC).

Table 5.7. Summary of drivers behind the installation of P stripping (excluding Yorkshire Water)

Driver	Total No	%
UWWTD	153	75.7
SSSI Only	28	13.9
HD Only	17	8.4
Other	4	2.0
TOTAL	**202**	**100.0**

The remaining 2% were required by:

– Environment Agency River Quality Objectives;

– Environment Agency Local Priority Schemes.

There were also a number of P stripping schemes introduced as a result of the UWWTD in conjunction with other directives. These were:

– Freshwater Fisheries (named as a driver in 26 schemes);

– Surface Water Abstraction Directive (2 schemes);

– Bathing Water Directive (1 scheme).

Thames Water has by far the highest percentage of STW with P stripping installed, (13.9%), whereas South West Water has the lowest (0.6% of STW). Thames Water has significantly more P removal schemes than other water service companies primarily as the non-tidal Thames was classified as a SA Eutrophic, therefore all STW >10,000 p.e., (of which there are approximately 70) are required to remove P. As Thames Water serves London and surrounding conurbations, it is unsurprising that it operates the largest number of STW with P stripping installed.

5.5 Future P removal schemes

The next round of SA identification is currently in progress, and ministerial decisions are expected in early 2007. At present, 30 candidate SA (eutrophic) have been identified, of which approximately 66% will be in the Midland and Southern regions (Defra, 2006). The number of STW that will be affected is unknown.

There were a number of STW upgrades this study identified. As of May 2006, Wessex water were required to upgrade 3 plants, whilst during AMP4 (2005-2010), it is expected a further 19 STW within their region will have tertiary treatment installed. A further 17 Southern Water STW will have P removal by 2008, whereas Northumbrian Water will upgrade 3 STW by the same date.

It is likely that in accordance with the UWWTD, tertiary P stripping will only be introduced at STW with p.e. >10,000 (Jarvie et al., 2005). To do so at smaller STW may be financially unacceptable. This strategy is likely to decrease total P loads entering UK watercourses, but will exclude many rural STW discharging significant P loads where the cumulative impact of smaller discharges (i.e. septic tanks, smaller industrial discharges etc.) may have increased significance and present the greatest risk to the chemical and ecological quality of the riverine environment. It may be prudent to look at combined discharge to catchment rather than individual discharge to catchment (Jarvie et al., 2005).

In conjunction with reducing P concentrations in STW effluents, it would also be sensible to reduce P concentrations within STW influent. A number of options exist, including:

– Reducing P in domestic detergents. Replacing sodium tripolyphosphate (STPP), the main P containing constituent, with zeolites. This approach has been adopted successfully in numerous EU Member States;

– Separation of urine and faeces. Urine has approximately double the P concentration of faeces (Rybicki, 1997) and could be effectively treated separately.

5.6 Consent Requirements

In conjunction with the introduction of new nutrient stripping schemes, limits for existing consents are likely to be progressively reduced. For example, Wessex Water will be reducing consents in many STW to 1mg/l-1, due to classification as a Special Area of Conservation (SAC). Current consent requirements of UK STW with P stripping are shown in table 5.8.

Table 5.8. P consent requirements

Water Company	1mg/l	1.5mg/l	2mg/l	3mg/l	Other/unknown
Anglian	3	2	3	36	0
Dwr Cymru	0	0	5	0	3
Northumbrian	0	0	8	0	2
North West	5	0	3	0	3
Severn Trent	15	0	24	0	0
Southern	0	0	16	0	0
South West	0	0	1	0	1
Thames	6	0	36	0	7
Wessex	1	0	20	0	0
Yorkshire	5	0	6	0	0

57.8% of STW with P stripping installed adhere to a 2 mg-P l^{-1} limit, whereas 16.6% are required to conform to a 1 mg-P l^{-1} limit.

5.7 Total nitrogen removal in the UK

The tertiary removal of total N at UK STW is rare, at the end of AMP3 (2000-2005), there were no STW in England which had total N removal installed; the only STW with Total N removal consents which this study were identified were in Wales, representing 0.3% of Welsh STW (0.07% of total UK STW). The primary method of Total N removal is via a step-feed process, aerobic nitrification is followed by an anaerobic denitrification stage. A number of Water service companies remove ammoniacal nitrogen, usually to 1-5 mg - P l-1 (Pearce, pers comm. 2006) but figures detailing extent were unavailable for analysis.

5.7.1 Future N removal schemes

Proposed nitrogen SA data was not available for analysis, but it is possible that a number of water service companies may be required to install Total N removal due to new SA notifications. Certain areas of the Thames estuary may be designated SA (Nitrogen), thus Total N removal would be required. A number of Wessex Water STW (notably Poole STW) will be required to remove Total N by December 2008 and it is expected that a 10 mg-N l-1 limit will be required. This will be done through tertiary filtration process using methanol dosing, thus providing a carbon input to aid in the denitrification process. It is expected that Southern Water will be required to perform Total N removal at 6 STW from March 2008, whilst Northumbrian Water plan to upgrade Billingham STW to perform N removal (adhering to a 10mg-N l-1 limit as prescribed by the Habitats Directive, rather than the 15mg-N l-1 UWWTD limit). The likely process method will be to employ an extended activated sludge system with anoxic zones for nitrification/ denitrification.

6.0 Summary and needs for development

6.1 Conclusions

This report has identified current UK practices for both mains connected and non-mains connected households in the UK, and given examples of common designs for various process options. All stages of sewage treatment have been presented and the relative merits of each process option assessed. Explanation of suitability regarding different population to be served has been provided, as have selection and project management procedures. This report would serve as a useful starting point for a party wishing to construct a sewage processing scheme, before advice from environmental engineer/environmental regulator was sought.

It was found that the majority of UK households, approximately 98%, are connected to the mains sewerage network, thus have no need to consider sewage processing options. For the remaining 2% it appears that the septic tanks are the most popular option (1.7% of unconnected households) followed by private STW (0.3% of unconnected households). There is concern regarding the state of the private sewer network that connects many rural households to main sewers. Many private sewers are in a state of severe disrepair and liable to failure in the near future. Any sewer failure may present an unacceptable risk to the local ecology. It was also found that ownership of private sewers was often disputed, potentially contributing to neglect and degradation. A rationalisation of the private sewer network is desirable in order to limit further neglect and mitigate potential ecological degradation.

The UK appears to be behind other EU Member States regarding implementation of the UWWTD. Introduction of nutrient stripping schemes at UK STW has been slow, being primarily driven by prescriptions contained within the Directive. It is believed by the EU commission that many more UK STW require installation of nutrient removal facilities and % of total STW load subject to tertiary treatment is significantly less than other EU Member States. Where nutrient stripping is carried out, it is primarily done to remove phosphorus and the dominant method is chemical precipitation by addition of iron salts.

It has been clear whilst undertaking this investigation, there is a lack of centralised official information regarding the whereabouts and details of private sewage treatment schemes. As approaches to both the Environment Agency and Local Authorities for information proved unsuccessful, this study was forced to rely mainly on existing literature. Undoubtedly monitoring of private sewage treatment schemes is undertaken by the Environment Agency and the Local authorities, but more effort needs to be concentrated on collating existing data and centralisation of information.

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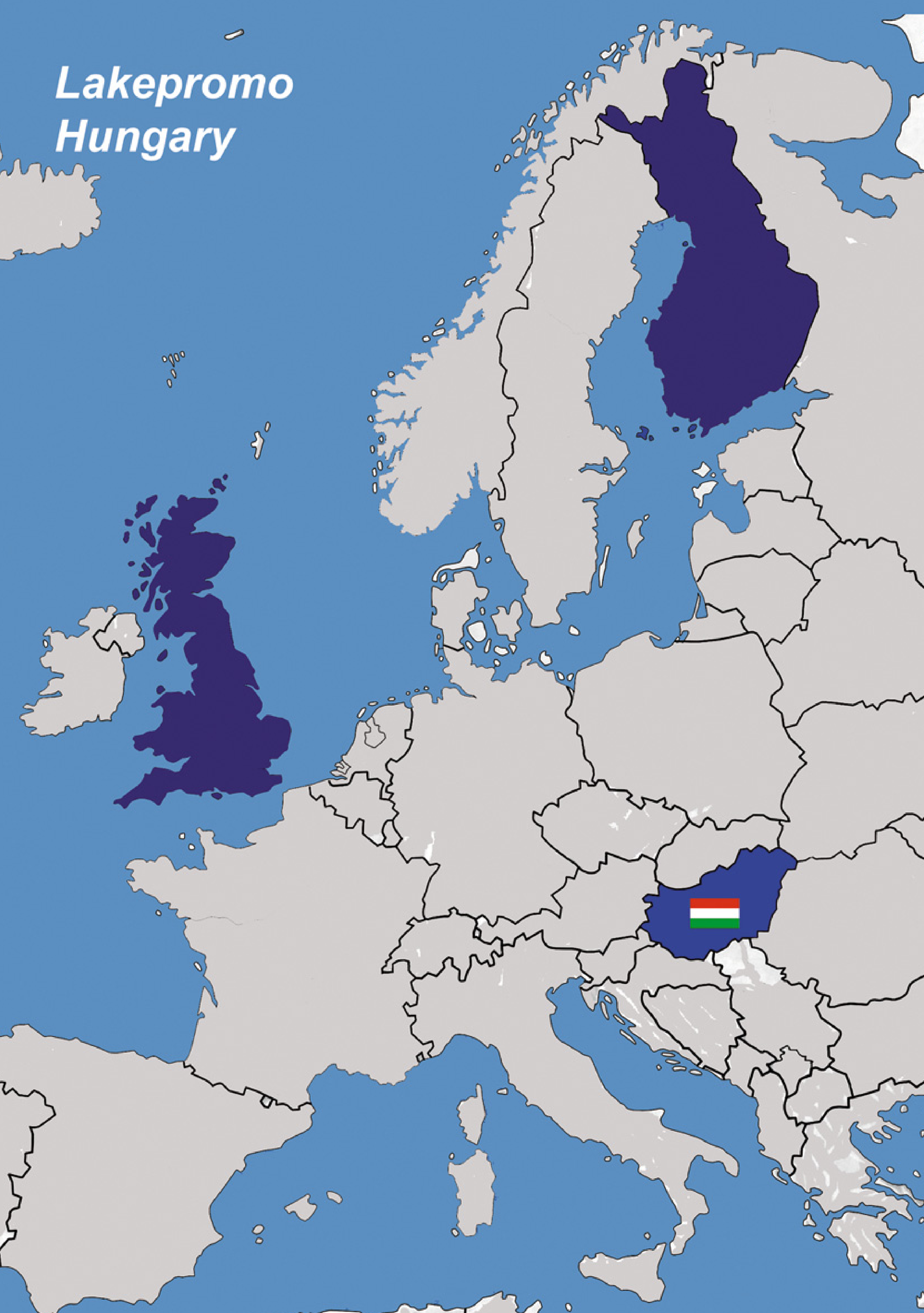
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RURAL WASTEWATER TREATMENT IN HUNGARY

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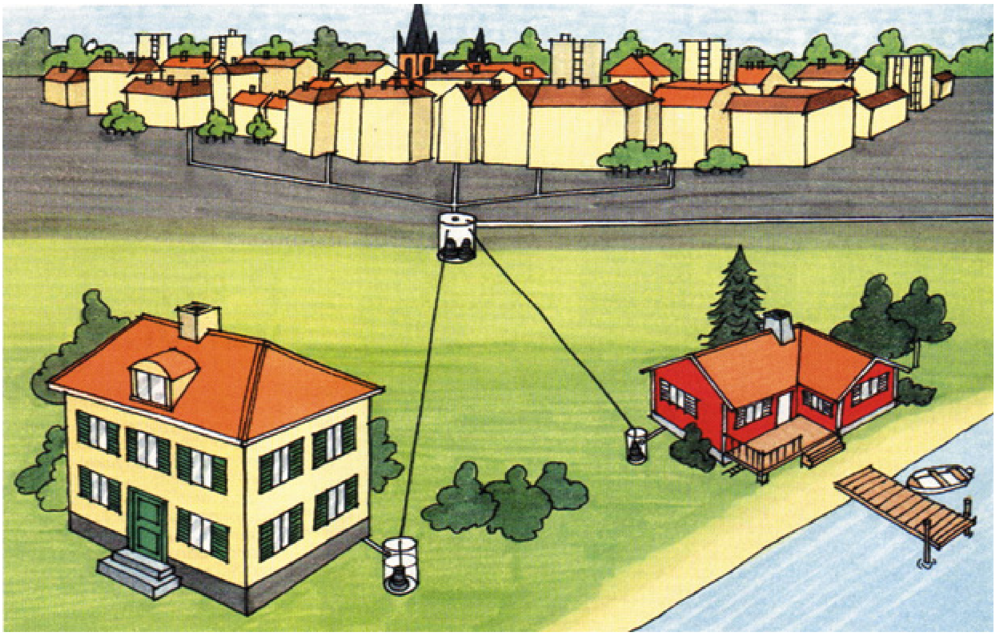
for Lakepromo Interreg IIIC Rural SewageTreatment
sub-project



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Contents

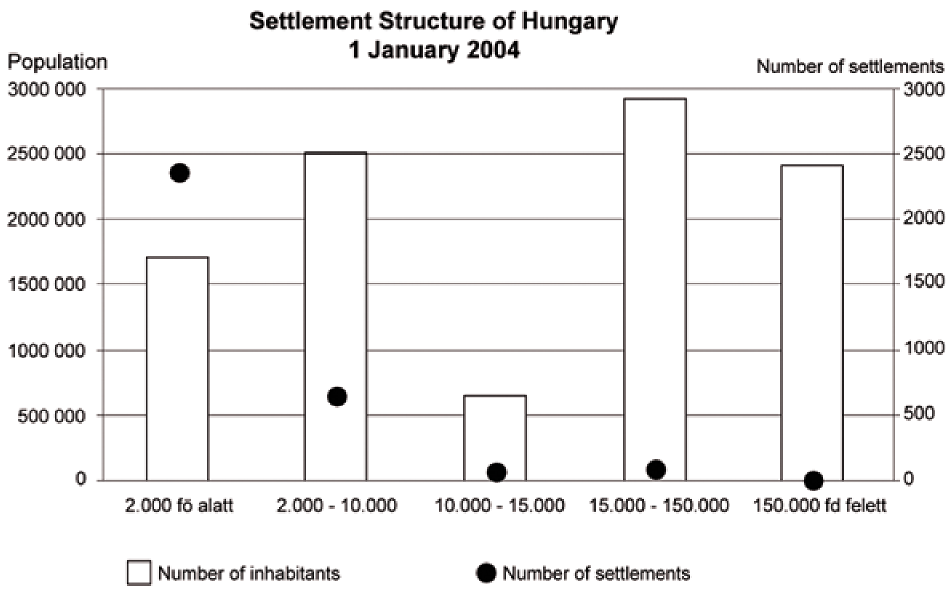
1. Background

96% of Hungarian surface waters comes from outside the country. Due to this the quantity and quality of Hungarian surface water largely depends on the interventions made in our neighbouring countries. In the rate of the load/pollution of our surface waters communal waste water plays a significant role

Protection of groundwaters is a strategic task while more than 90% of our drinking water supply comes from groundwaters. The quality of these is endangered mainly by the agriculture (use of chemicals) and the communal origined polluting matters. At the areas without sewerage the traditional domestic waste water storing chambers cause significant pollution in the groundwaters.

Settlement Structure of Hungary

It can be stated that the proportion of settlements with population equivalent under 2000 is high (74,7%) but in these concentrates only 16,8% of the population.



Target state

		Normal areas A. Living waters and firths		Sensitive areas A. Living waters and firths		Totally	
	Emission sites Agglomerational class	Number of affected agglomerations/ settlements	Total PE (population equvivalent)	Number of affected agglomerations/ settlements	Total PE (population equvivalent)	Number of affected agglomerations/ settlements	Total PE (population equvivalent)
1	2 000 PE 10 000	482	638 268	14	14 638	496	652 906
2	10 000 PE 15 000	51	131 536	3	5 714	54	137 250
3	15 000 PE 150 000	112	602 241	4	22 454	116	624 695
4	More than 150 000	15	289 023	1	10 467	16	299 490
	Totally	660	1 661 068	22	53 273	682	1 714 341
5	**Less than 2 000 PE**	**1483**	**693 673**	**180**	**42 944**	**1663**	**736 617**
	Individual sewage treatment totally	*2143*	*2 354 741*	*202*	*96 217*	*2345*	*2 450 958*

2. Waste water collection and treatment situation in Hungary

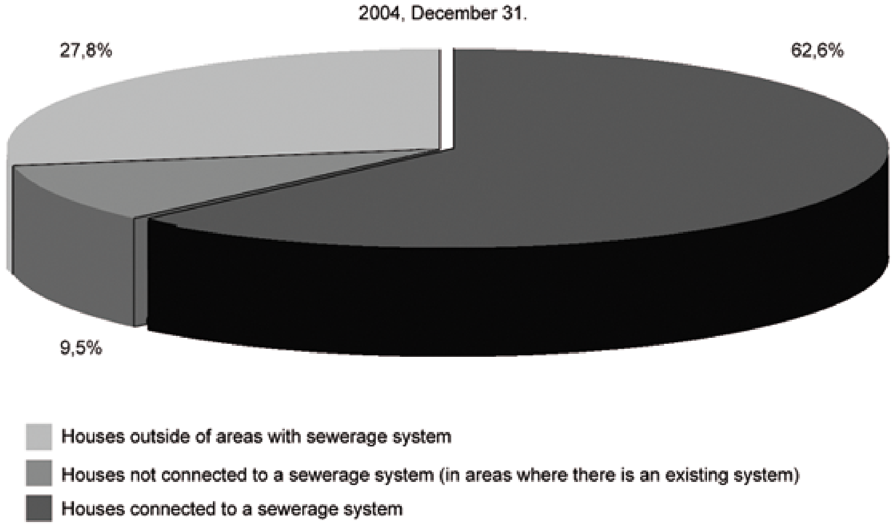
In Hungary, before the change of the political system (by the end of the year 1990) the number of homes connected to the sewerage system was only 41,6%, 429 settlements were connected to the sewerage system. At the same time the number of households connected to the drinking water system was 84,9% and 2431 settlements had drinking water system. So in case of both infrastructure component Hungary had great tasks.

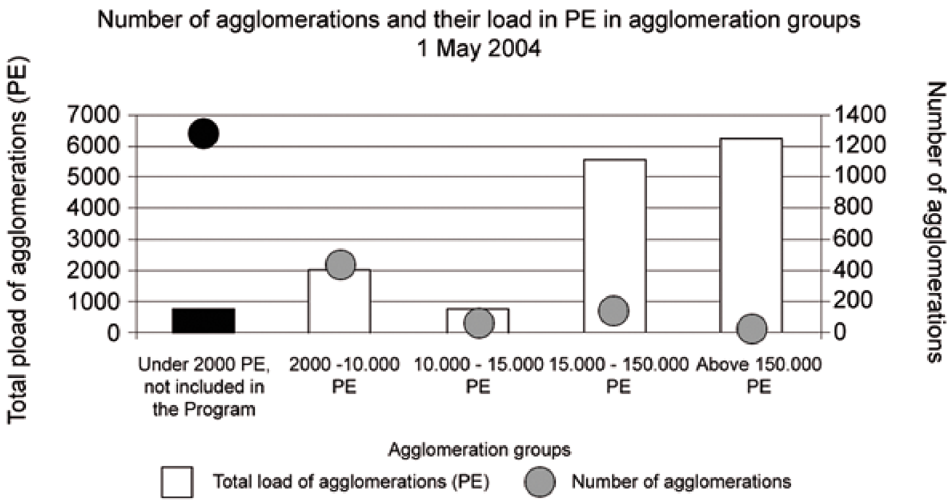
In Hungary, the number of homes connected to the sewerage system was only 56.1% by the end of the year 2002, despite intensive developments since 1993. In 2002, the public utility gap was 36.9%, which means that wastewater collection considerably lags behind public utility water supply. This lack of, and in many cases improper, wastewater collection endangers potential drinking water resources. In the period between 1994 and 2000, the length of the sewerage network increased by approximately 7,500 km to 22,300 km. By the end of the year 2002, the ratio of biologically treated communal waste water increased to 61%, and 32% of biologically treated waste water (19.5% of the total waste water) underwent tertiary treatment. In 1992 an intensive development program has started to meet the requirements of the EU at latest by 2015. From 2000 further developments were made, municipal associations (agglomerations) were formed to develop a sewage or waste water cleaning system together while this could be more effective and economical.

Settlements forming agglomerations in Hungary

Date	Settlements belonging to agglomerations above 2000 PE		Settlements belonging to agglomerations under 2000 PE		Total	
	amount	%	amount	%	amount	%
31 December 2000	1472	47	1667	53	3139	100
31 December 2002	1749	55	1410	45	3159	100
1 May 2004	1891	60	1268	40	3159	100

2.1 Sewage in Hungary (%)





Agglomeration group	Number of agglomerations	(%) of agglomerations	Total waste water load (thousand PE)	% of total waste water load
Under 2000 PE without EU obligation	1268*	65,7	749	4,90
2.000-10.000 PE	449	23,2	2012	13,16
10.000-15.000 PE	60	3,1	744	4,87
15.000-150.000 PE	136	7,0	5563	36,38
Above 150.000 PE	15	0,7	6222	40,69
Total:	**1902**	**100,00**	**15290**	**100,00**

In Hungary in the field of waste water cleaning the lag is even larger than in case of canalisation. In case of 1/3 of collected waste water there's no treatment and there are operational problems of biological waste water treatment plants.

Out of Hungary's task in relation with our accession to the European Union (EU) the most development is required in the field of waste water treatement and sewerage. The EU regulates the waste water diversion and treatement in the 91/271/EC Directive. According to it's instructions the tasks to complete and their deadlines concerning Hungary are the followings taking into consideration the derogation in the Accession Treaty:

- Until 31 December 2010 - agglomerations with a population equivalent of more than 15000 must be supplied with sewage network and biological (2nd level) waste water treatment plant
- Until 31 December 2015 - agglomerations with a population equivalent of 2000 - 15000 the collection of waste water and at least the biological (2nd level) waste water treatment must be solved
- Until 31 December 2008 - agglomerations with a population equivalent of more than 10000 in sensitive areas: the sewage network, biological (2nd level) waste water treatment and 3nd level treatment (N and P removal) must be solved
- For agglomerations under 2000 PE load a Individual Sewage treatment National Feasibility Program - 174/2003(X.28) Government Decree was developed but the directive does not give a deadline for the building of treatment plants, sewage network or individual wastewater system. The 174/2003 decree states that after 1 January 2006 new building can be established only with individual wastewater treatment if there is no canalisation.

The program available for the realization of the commitments steted in the Directive is called National Programme for Harmless Placing of Local Sewage which was accepted by two government decree:

- 25/2002. (II. 27.) Government decree : National Implementation Program of Urban Waste Water Collection and Treatment ("A" program),

- a 174/2003. (X. 28.) Korm. rendelet : Individual Sewage treatment National Feasibility Program: relating to areas which can to be provided economicaly with centralized sewage and cleaning system ("B" program).

The 25/2002 government decree contains the categorized list of identified agglomerations and the applied deadlines of sewage collection and treatment developments of the settlements.

The "A" and "B" program together substantiate the realization of the professional treatement and harmless placement of the waste water of all settlemets in the country.

In Hugary the 240/2000 (Xii.23) Government Decree regulates the identification of sensitive surface waters from the angle of waste water cleaning and their catchment areas. Main goal is the protection of surface waters from eutrophication. In the annexe 1 of this decree the the list of sensitive surface waters can be found (Lake Balaton, Lake Velencei, Lake Ferto) and in Anexe 2 the list of settlements on the catchment area of sensitive surface waters. Hungary is a Member State of the EU since 1 May 2004 so an actualized new program has been developed 30/ 2006. Government Decree.

2.2 Domestic waste water cleaning systems

The environmental friendly alternatives of the in these days general sewage system + waste water treatement plant are the followings:

- **near-natural waste water cleaning** methods of areas with sewage system and
- waste water treatement with **modern domestic waste water units** in areas without sewage system.

The common characteristics of both alternatives is that the pollutant matter in the waste water dissolve due to the activity of micro organisms which are found in nature so there is no need for external energy input.

The differentiation of the two category is justified by the different areas of application, the different forms, size and costs, or rather the necessarily different professional and legal regulations. Based on this and the professional traditions the a near-natural waste water cleaning belongs to the "A" programhoz, the modern domestic waste water treatement belongs to the "B" program.

Glossary

According to the "B" program local waste water treatement of areas which can to be provided economicaly with centralized sewage and cleaning system has technically and technologically segregated three main possible solutions:

- modern waste water treatement (so-called small units),
- use of a waste water cleaning unit and
- collecting the waste water in a closed container and shippment (urban liquid waste).

domestic waste water treatement
domestic waste water treatement units
domestic waste water cleaning units
domestic waste water storing closed chamber

From the above mentioned only the use of domestic waste water storing chambers has tradition in Hungary. But the one-two decade of use brought to surface a lot of economical and environmental problem. For example the illegal discharge of sniffing trucks, limited volumetric capacity of waste treatement and waste water cleaning units, the unaffordable transpirtation prices for the public etc.

Due to this the future support of this type of waste water treatement - only if securing workmanship and lack of centralized sewer system - only justified in areas where the domestic waste water cleaning can not be done due to the increased protection of water base. (eg. particularly sensitive underground water areas).

Units developed and used in the developed countries are available in the Hungarian market and for the wide domestic use the posibility of creating their centralized subsidization is in progress.

2.3 The possibility of using domestic waste water treatement unit depending on the local area conditions

System		Local conditions					
		Normal local conditions	Problematic areas				
			Permeability of the ground is low	Shallow sand bed on impenetrable base rock	Shallow sand bed on fragmented base rock	Permeability of the ground is high	High groudwater
2 phase	1. Septic tank with conventional (made in local ground) deposition field	Yes	Yes	No	No	No	No
2 phase	2. Septic tank with conventional (made in local ground) deposition field, feed pump	Yes	Yes	No	No	No	No
2 phase	3. Septic tank with shallow,sand filled ditch type deposition field, feed pump	Yes	Yes	Yes	Yes	Yes	Yes
3 phase	4. Septic tank with alternate working sand filter, conventional (made in local ground) deposition field	Yes	Yes	Yes	Yes	Yes	Yes
3 phase	5. Septic tank with alternate working sand filter, conventional ditch type(made in local ground) deposition field, feed pump	Yes	Yes	Yes	Yes	Yes	Yes
3 phase	6. Septic tank with alternate working sand filter, shallow infiltration ditch, feed pump	Yes	Yes	Yes	Yes	Yes	Yes
3 phase	7. Septic tank, with sand filter, hill type deposition field, feed pump	Yes	Yes	Yes	Yes	Yes	Yes

2.4 The probable cleaning result of each element of the domestic waste water treatement units in concentration of pollutant matters:

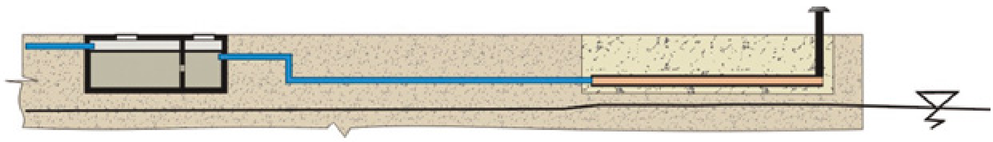
Parameter		Raw waste water	Effluent of the septic tank	30 cm under the floor of deposition field	90 cm under the floor of trickle ditch	Effluent of the intemittently running sand filter	Effluent of the recirculatory gravel filled filter
Organic matter(BOI5)	mg/l	210-530	140-200	0	0	<10	<15
Floating matter (LA)	mg/l	237-600	50-90	0	0	<10	<15
All nitrogen(TKN)	mg/l	35-80	25-60	-	-		
Ammonium (NH3-NH4+)	mg/l	7-40	20-60	20**	-	<0,5	<0,5
Nitrate (NO3-)	mg/l	<1	<1	40**	40**	25	25
All phosphorusr (Ptot)	mg/l	10-27	10-30	10**	1**	10^2-10^4	
Infectious bacteria (Fecal coli)	MPN/ 100 ml	10^{6}-10^{10}	10^3-10^{16}	0-10^2	0	10^2-10^4	10^2-10^4
Virus	PFU/ml*	Unknown	10^5-10^7	0-10^3	0	n.a.	n.a.

* PFU - plaque forming units
** the number is changing between the given value and the marginal value

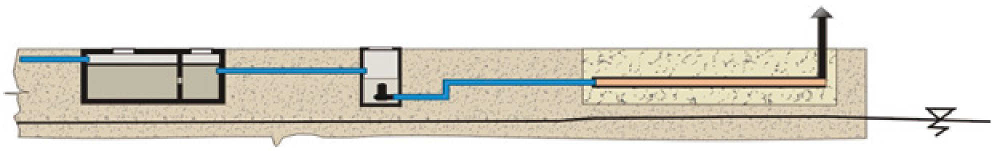
3. Domestic waste water treatement units

3.1 Technological characteristics

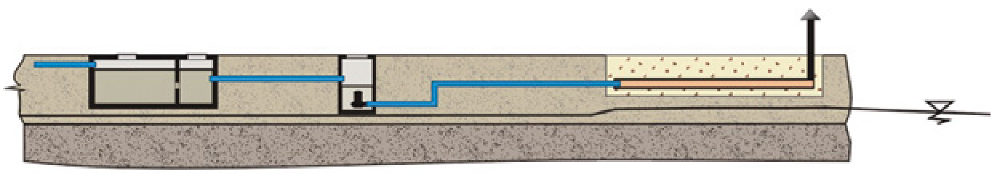
1. Simple septic tank and traditional (made in local ground suitable for desiccation) drained desiccation system



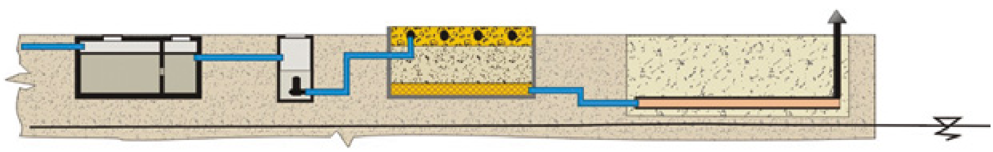
2. Simple septic tank and traditional (made in local ground suitable for desiccation) drained desiccation system with feed pump



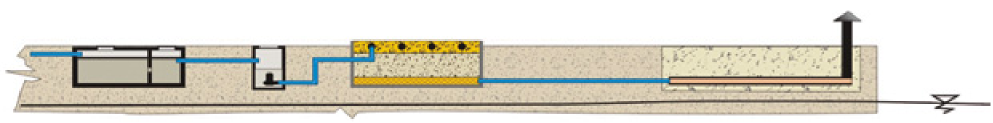
3. Augmented septic tank, shallow sand filled ditch type desiccation system, feed pump



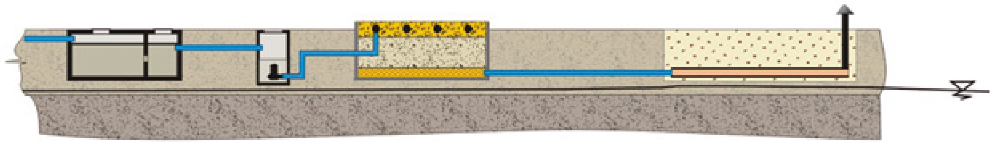
4. Augmented septic tank, alternate working sand filter, traditional (made in local ground suitable for desiccation) drained desiccation system



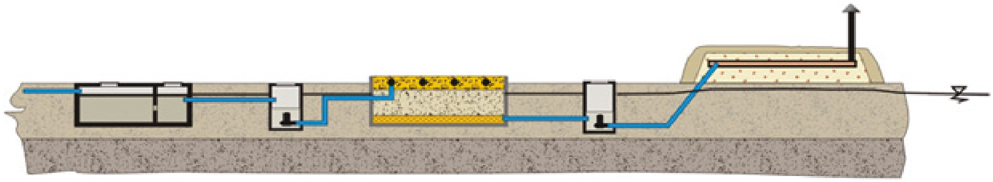
5. Augmented septic tank, alternate working sand filter, traditional (made in local ground suitable for desiccation) sand filter ditch desiccation system, feed pump



6. Augmented septic tank, alternate working sand filter, shallow desiccation ditch, feed pump

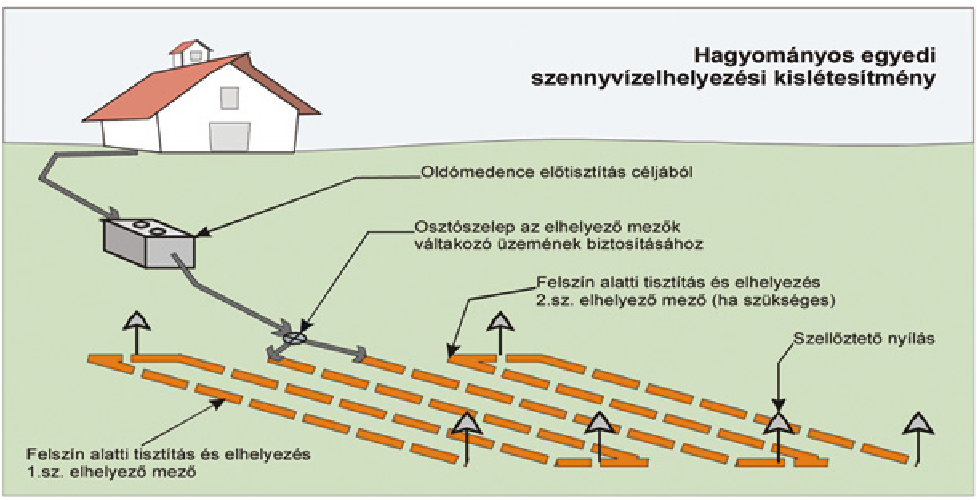


7. Augmented septic tank, sand filter, hill type system, feeder pumps



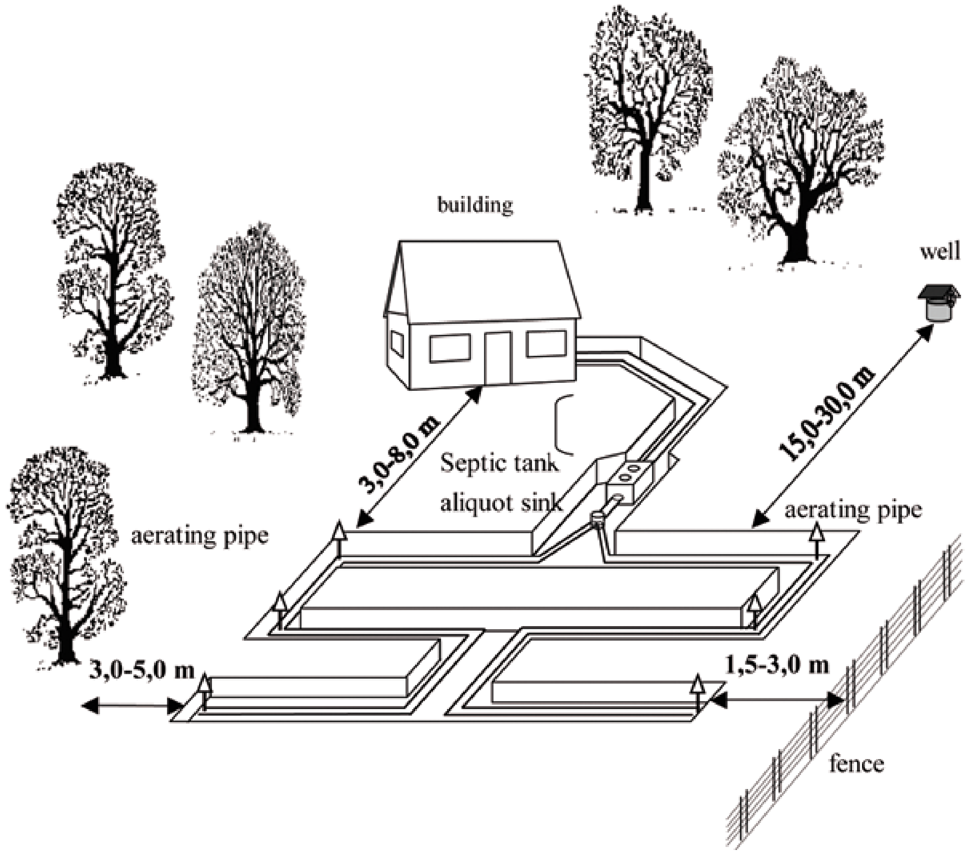
3.2 Traditional domestic waste water treatement unit

(for details pls. see table in next page)

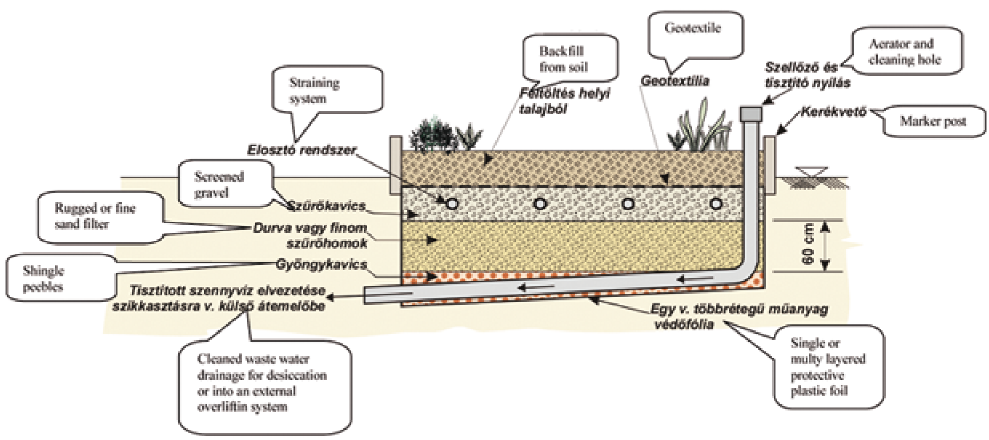


Functioning and main parameters of the domestic waste water cleaning system:	
Septic tank	**Recleaner and placing field**
Tasks: pre-sedimentation -sedimentation and desbris removal -anaerob and oxigen free organic matter decomposition (cold putrefaction, without heating and mixing)	-subsurface ground absorption system which is generaly a series of shallow 0,6 - 1,5 m)ditches filled with granular material (grail, gravel).
Contruction: -water proof was at sight or prefabricated -armoured concrete or plastic	**The essence of cleaning:** decomposition of organic and inorganic pollutants -with biologocal, hysical and chemical processes -into water,nitrogen,gas,carbon dioxide etc.
Build-up: -single chamber with efferent filter or -bilocular with baffle wall	**Role of the filling:** - maintain the structure of the ditch - partial cleaning of the waste water - allocation of the waste water to the ground - equalization of peak downflows **Way of dispense**: -gravitationaly by turns - by feed pump periodically - by feed siphon

Protective distance of the filter-positioning field:



Example of a structural design of an intermediary filter:



3.3 Near-natural waste water cleaning methods, local situation and necessity of supporitng its adaptation

Main types of near-natural waste water cleaning methods:

- tree plantation (quick infiltration),
- pond (lagoon),
- built hydrophytes (built wetland)
- and the combination of the above mentioned.

Surveying of the Hungarian use of near-natural waste water treatement methods were made by the Environmental Office in cooperation with the inspectorates in 2002 and by the Budapest Technical University in 2004. The surveys reported although not in full accordance a number of 122-126 near-natural waste water treatement plants of which the majority (15-50 %) at that time was not used for waste water treatement, this amount increased with time.

63 % of the built plants was aspen, 27 % pond, 10 % root field.

49 % of the plants was made for treating waste water from food processing industry, 38 % for communal waste water and 9 % for treating liquid manure. Only 70% of the plants operated sufficiently and only two operated excellently both in the are of the Lower-Danube valley inspectorate. In the higher amount (35) near-naturel waste water cleaning plants were built in the area of Upper-Tisza inspectorate, all with satisfactory operations.

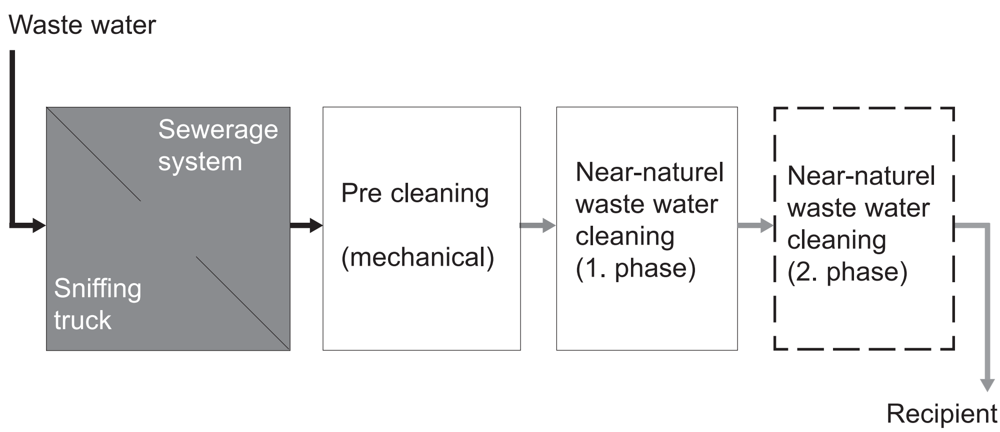
The marked reason of the relatively high (30%) non satisfactory operation were predominantly the deficiencie of the operation-maintenance, the over or under charging, moreover the lack of operators but there were cases where the operational malfunction was due to the wrong planning and building. During the surveys general experience was that the monitoring systems were not built adequately. Also the illegal delivery and deposition of urban waste water endangers the operation of these plants.

What retards the realisation of the near-natural waste water cleaning methods?

According to the Hungarian Ministry of Environment and Water there is no legal barrier for the adoptation of the near-natural waste water cleaning methods but the adoptation of their use is obstructed by the followings:

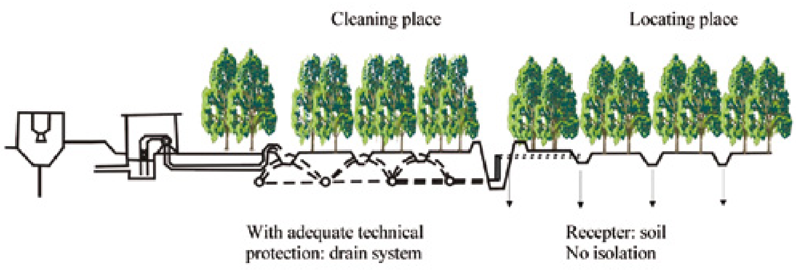
1. The practice and the subsidies, supports of the traditional canalisation and the traditional waste water cleaning methods is existing but this can not be said about the near-naturel waste water cleaning methods. The water usage permission does not cover economical monitoring and the consideration the financial admissibility is the competence of the municipalities. The decisionmakers at the municipalities does not posses the adequate professional, technical knowledge during the decisionmaking of an investment, this could be avoid with recommendations from the authorities. Due to government subsidies the municipalities do not try for cheaper investments and ones with lower operational cost.
2. The artificial solutions are more expensive , higher subsidies could be get for them and overlap with the short term interest of the participants (municipalities, producers, designers and contractors).
3. Subsidies could be get for the liquidation of the near-natural waste water cleaning units and for building an artificial waste water cleaning plant (in the beginning of the 90's Gyula and in 2004 Nyírlugos).
4. The wetland built int he last ten years are not good examples while at the majority there are cleaning efficiency problems which are due to the lack of technical planning/design experience.
5. It is also a problem that there are a lot of administrative barriers during the building of a near-natural waste water cleaning plant.

Main components of the near-naturel waste water cleaning systems:

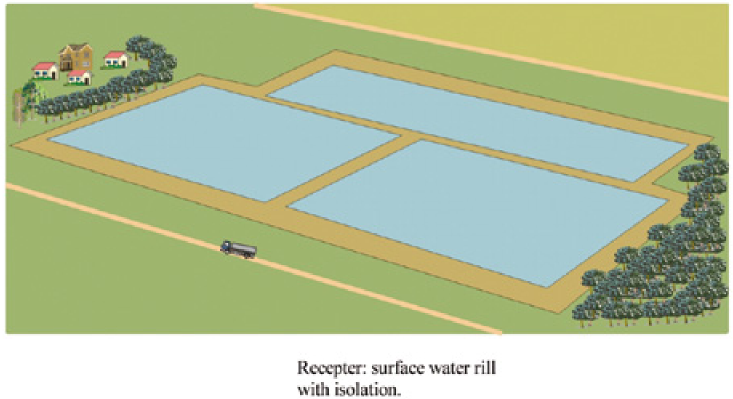


Main types of the near-natural waste water cleaning systems:

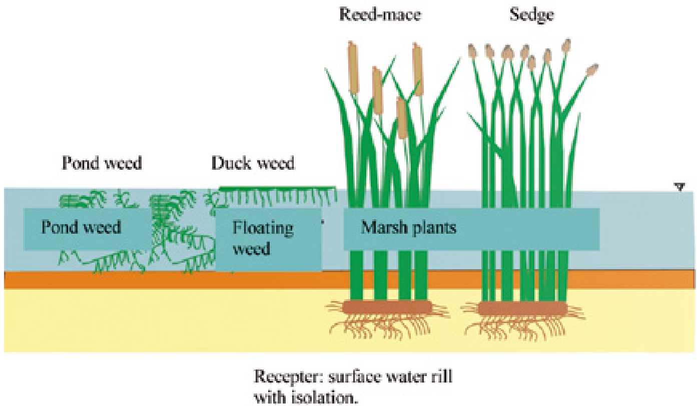
- Tree plantation system



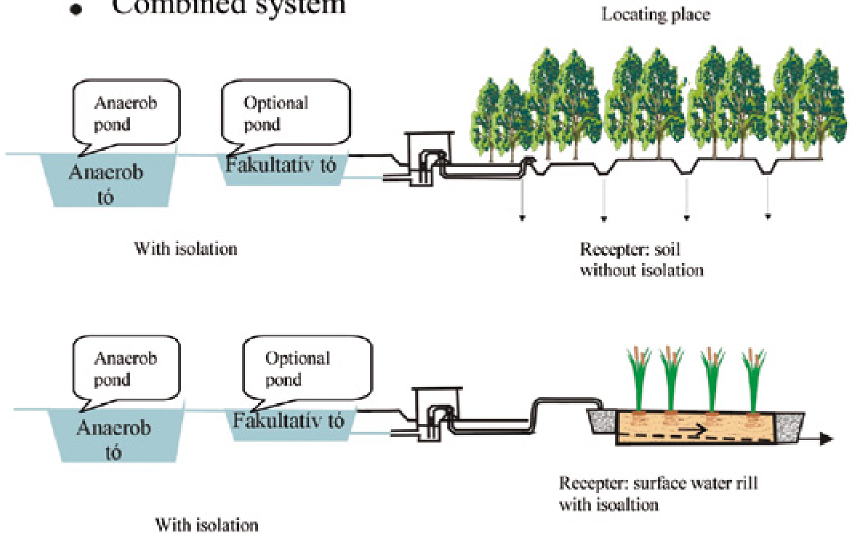
- Pond system



- Built hydrophyte system



- Combined system



Subsidies, supports:

From 2006 the local Environment and Water Target Allowance support ended while the subsidied were decentralizated to the regional development commitee and to the county developement commitee.
The decentralizated provisions in the case of "waste water sewage and cleaning" and "producing infrastructure" subsidies assures possibility for the planning and realization of natural waste water treatment and rural, domestic watewater treatemnts based on the following laws:

- 90/2004. (IV.25) Government decree
- 27/2005. (II.14) Government decree
- 19/2005. (II.11.) Government decree

In case of international subsidies there was a big change after Hungary joined the European Union (EU). The support of the realization of KOP (Environmental Operational Program) is made from the Europen Union Structural Fund. It is important that the EU did not seclude itself from supporting the domestic, rural waste water treatment methods.

Summary

The above mentioned domestic/local waste water treatement methods are widely used in countries who are in better economical position and far foregone in environmetal protection than Hungary. The possibility of use of these technologies is worth to condiser if:

- **the quantity of the waste water is low (small settlements and individuals);**
- **the local conditions (garound,soil and ground-water, size of site) make it possible;**
- **residential density low, building cost of common sewer is high.**

During the long run conception it should not be forgotten that even the adquately treated waste water could endanger the human healt and the environement. The cleaning and positioning of waste water is based on complex and complicated technologies so the adquate experise is needed during the
preparation and planning,
realization,
operation and monitoring
phases.

Decision made about waste water treatement is for decades so the responsibility of local goverments is enormous to find in line with environmental security the best and less expensive for the inhabitants.

In correspondance with the near-natural waste water cleaning method it can be determined that due to lack of a numerous, well operated, well publicated reference sites extensive reputation and use can not be expected. Result of the latest act change is that it made compromise for the quality of effluent during winter which was the greates barrier for the adaptation of this type of treatement and this might make both professsionals and investors move to the desired direction.

4. The New Hungarian Development Plan

Hungary take really serious commitments by becoming a Member State of the European union, therefore, on the area of waste water treatment as well. Sound investments have to be implemented within the committed period of time.

The problem of settlements under 2.000 PE, settlements in rural areas and small groups of households has not been addressed and committments do not include them. The solution for the existing problems is urgent. This solution is required to ensure the sufficient quality of life in rarely populated areas, to increase level of pollution and the decrease of the pollution of water and soil.

Both Environmental and Energy Operational programme (EEOP) and Regional Operational programmes (2007-2013 planning period) include solutions and plans concerning such area. Action Plans (2007-2008 within the timeframe of the planning period) assist the implementation of certain plans.
Financial budget for the investment includes EU sources, national sources and own contribution.

4.1 The Role of The New Hungary Development Plan

Discussions on the New Hungary Development Plan has been come to an end. Subsequently, now it is decided what kind of developments will be prioritised between 2007-2013 financial period. The document sets out main strategies and objectives for Hungary for the 2007-20013 period. The New Hungary Development Plan (short: NHDP) is to expand employment and to create the conditions for long term growth. For this purpose it launches co-ordinated state and European Union developments in six priority areas: the economy, transport, for the renewal of the society, environment and energy, regional development and state reform.

The Government also submitted 15 Operational programmes, by which almost 28 billion Euro is available for development. The operational programmes were submitted to the European Committee in December 2006. According to the plans, the most amount of finance will be provided for the Transport Operational Programme, **Environment and Energy Operational Programme (EEOP)** and the Social Renewal Operational Programme.

Operational Programmes of the New Hungarian Development Plan

- Economic Development Operational Programme
- Transport Operational Programme
- Social Renewal Operational Programme
- Social Infrastructure Operational Programme
- **Environment and Energy Operational Programme**
- State Reform Operational Programme
- Electronic Public Administration Operational Programme
- Implementation Operational Programme
- Regional operational programmes:
    - West Pannon Operational Programme
    - South Great Plain Operational Programme
    - North Great Plain Operational Programme
    - Central Hungary Operational Programme
    - North Hungary Operational Programme
    - Central Transdanubia Operational Programme
    - South Transdanubia Operational Programme

4.2 Environment and Energy Operational Programme (EEOP)

The Environment and Energy Operational Programme (KEOP) is one of the operational programmes which was made to serve the overall objective, the horizontal policies and six representational and territorial priorities of the New Hungary Development Plan (NHDP) concerning the European Union's budget plan timeframe between 2007 and 2013, - the National Strategic Reference Framework (NSRF) in EU terminology. The successful achievement of the New Hungary Development Plan is inconceivable without strengthening environmental protection. The basic aim of The Environment and Energy Operational Programme is to promote sustainable development in Hungary.

The considerations of the strategy of the KEOP are based on the following:

- to affirm environmental protection - solving certain environmental, nature conservation and water problems and its related arrangements - to improve the quality of life in the short and long term.
- developing the communal infrastructure as a sustainable system is giving an impetus to reform the economy and to establish territorial cohesion.
- the more efficient and frugal use of natural resources will further sustainable development and improve the competitiveness of the country.
- to create the above mentioned conditions in the regions is to assistance protect and develop the cultural and natural heritage in each region, especially in the more deprived areas, which are going to receive more opportunities to participate in economic development.

Budget of the Operational Programme

The Environment and Energy Operational programme concerns the following developments priorities:

1. Healthy, clean settlements
1.1 Utilization of wastes
1.2 Wastewater treatment
1.3 Aquifer protection and improvement of the quality of drinking water

2. Proper treatment of our living water
2.1 Satisfactory practice of flood protection
2.2 Qualitative and quantitative protection of our living water, contamination prevention of the living water
2.3 Arrangements of the government of accomplishing WFD (Water Framework Directive)

3. Proper treatment of our natural assets
3.1 Preservation, restoration and developments of protected natural assets and areas which have general significance for the community,
3.2 Creation of the infrastructure base (investments) in habitat, agriculture and forestry preservation
3.3 Reduction of deterioration and damaging impact on the landscape caused by railway facilities
3.4 Development of the forest school network

4. Increase of renewable energy usage

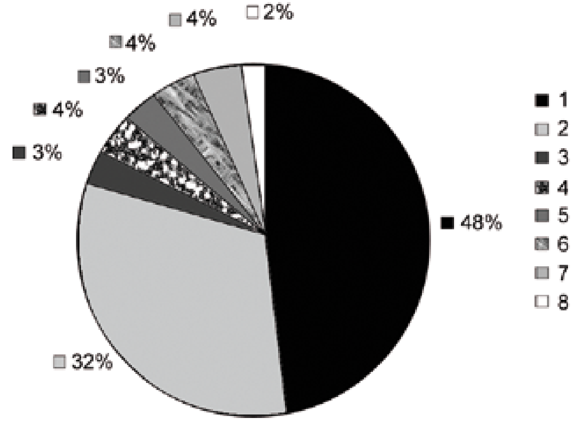
5. Efficient energy usage
5.1 Modernization of energy usage of municipal and non-municipal public buildings
5.2 Modernization of gas heating systems
5.3 Modernization of energy systems in the commercial sector (industry, energy industry, service sector)

6. Promotion of sustainable production and consumption habits
6.1 Sustainable production
6.2 Promotion of sustainable consumption
6.3 Developments connected with the targets of e- nature conversation

7. Project preparation

8. Financing the management of the operational programme (technical assistance)

The following diagramme indicates the budget allocation of the Operational programme for the 2007-2013 financial period.



It can be seen, that the dominant part of the programme is the development and the establishment of a healthy, clean settlements, including the improvement of the wastewater system.

Connection with other operational programmes

Main connection can be found as regards Regional Operational Programmes concerning individual waste water treatment.

Regional Operational Programme (ROP) connection

The following communal development plans are being implemented (not independently, but as part of other priority axes) in the regional operational programmes:

- Part of settlement rehabilitation: protection of cultural heritage, dust-free in-town roads, revitalization of green lands for the community, shaping new green areas, planting trees, precipitation drainage in towns, network reconstruction of wastewater treatment systems.

- ***Wastewater treatment of agglomerations and towns, with less then 2000 people: using various technical solutions, as part of the Individual Wastewater treatment National Development Programme by advancing establishment of small environmental friendly cleaning systems and professional individual placement of sewage water; liquid waste collection and management by the same axes.***

- Damage reduction of polluted areas connected to brown-field investments as part of settlement rehabilitation and the development of the economy.

- Eco-tourism developments (connection to national parks, water conservancy, botanical gardens, and other protected areas).

- Arrangements to save energy for the inhabitants (included in integrated town district rehabilitation plans)

- Implementation of environmentally friendly regional transport infrastructure.

- Conservation and promotion of local environmental values, introduction of environmental programmes connected to developments. Expanding Green Point network system, creating regional environmental-information centres and databases.

- Asbestos abatement in private and local administration residences, community buildings, including removal of insulation containing asbestos, and secure disposal of this waste.

- Qualitative and quantitative protection of our waters, arrangements in regionally significant water protection areas:
    - Riverbed rehabilitation to reach the "good condition" - renewing water, improving water quality, rehabilitation (Building and reconstruction of rivers reservoirs, waterbed and flood-plain reconstruction, lakes, dead channels and tributaries)

    - Preventing the further pollution of surface water and under surface water. (Governmental reclamation of activities related to mining; forming protective systems (according to 219/2004. government regulation) in the case of depositing dangerous pollutants.

    - Holding back the water, renewing the water, and back-feeding, to reach the "good condition" (development of inland water usage as aquifer for drinking water, regional water reservoirs, renewal and restoration of water, rehabilitation of the water system.

4.3 Review of the Regional Operational Programmes with special attention to waste water treatment in settlements less than 2000 PE

There are 7 regional operational program for Hungarian regions:

- West Pannon Operational Programme
- South Great Plain Operational Programme
- North Great Plain Operational Programme
- Central Hungary Operational Programme
- North Hungary Operational Programme
- Central Transdanubia Operational Programme
- South Transdanubia Operational Programme

West Pannon Operational Programme

The West Pannon Operational Programme contains several priority axes:

- Regional economic development
- Tourism development
- Urban development
- ***Environmental protection and transport infrastructure***
- Development of local and regional public services

Waste water treatment is a key element of the environmental protection and transport infrastructure priority axe.

Wastewater management of small settlements

Due to the settlement structure of the region, the number of settlements with a load below 2,000 resident equivalent (RE) is low. These settlements are located far form each other and in isolated areas, and in many cases in areas with a water base that is especially sensitive and frequently visited by tourists. While the implementation of a sewage network in cities and densely populated areas is not only essential, but also economic, the method of wastewater management in small settlements and sparsely populated areas must be evaluated for the purposes of both economics and environmental protection. Since it is not necessary to apply a complex sewage system connecting several settlements and central wastewater cleaning in all cases within these areas, we are ensuring that wastewater is retained and treated locally.

Indicative list of types of operations:

Development of natural wastewater cleaning and public utility replacement equipment, individual wastewater cleaning, wastewater management and wastewater placement in the case of small settlements [below a residential equivalency value of 2000 according to Governmental Decree 25/2002 (February 27)], and settlements outside of wastewater treatment and the conurbations:

- Investment aimed at natural wastewater cleaning and the construction of a related public sewage system (for example, solutions consisting of tree plantations, lakes, root zones, and their combination)
- Traditional (artificial) wastewater cleaning processes and the construction of the related sewage network
- Facilities of professional individual wastewater placement: unique small

wastewater deposit facilities, unique small wastewater cleaning equipment.

- The optimized and combined solutions of the above.

- The support of project preparation activities related to each action

By achieving the targets of the programme, 15 000 people would recieve wastewater management.

South Great Plain Operational Programme

South Great Plain Region Operational Programme includes the following priority axis:

- Regional economy development
- Tourism developments
- Development of transport infrastructure
- Human infrastructure development
- Regional development actions
- Financing of the south great plain operational programme (technical assistance)

Waste water treatment is connected to regional development within the Operational programme.

Renewal of the settlement network's infrastructure is an indispensable precondition of a region's development, and so are the expansion of service functions of cities that drive business in the region, the increase of employment and the establishment of liveable and healthy neighbourhoods.

Rural development actions will provide for new individual waste water treatment technologies int he frame of the following actions:

> Waste water treatment with a mixture of technologies at settlements and agglomeration areas with an inhabitant equivalent (I.E.) below 2,000, near-natural waste water purification and proper independent waste water treatment, preferably through small facilities and as part of the Independent Waste Water Treatment National Implementation Programme; Disposal of liquid communalwastes by road transportation,

arranging for treatment or establishment of waste water treatment plants.

North Great Plain Operational Programme

Priority axes:

- Improvement of the operational conditions of the economy
- Development of transport infrastructure of regional and local importance
- Strengthening of the potential of tourism
- ***Urban and regional development***
- Financing of the implementation of the North Great Plain Operational Programme (Technical assistance)

The intervention comprises developments aimed at the protection, preservation, improvement, reconstruction and the getting to know of local environmental heritage as well as those related to the development of the environment awareness and perception of the population and decision-makers and to information provided for them on environmental protection. A separate component of the intervention is assistance for the development of the infrastructure of environmental protection, and, within that, assistance to settlements with a RE below 2,000 in order for them to tackle the issue of waste water management, assistance for the establishment or upgrading of a system of protection against excess ground water in inner areas, developments related to noise abatement and air protection as well as project preparation.

Central Hungary Operational Programme

Priority axes:

- Innovation- and Enterprise-oriented Development of the Knowledge-based
- Economy
- Improvement of the Preconditions of Competitiveness
- ***Development of the Region's Attractiveness***
- Development of the System of Human Service Institutions
- Renewal of Settlement Areas
- Financing of the Implementation of the Central Hungary

Operational
- Programme (Technical Assistance)

Waste water program is targeted within the Development of the Region's Attractiveness priority axes. The development of the Region's system of environmental protection services has the following objectives: installation and application of individual and natural sewage treatment technologies for small communities (district and settlement parts, homesteads, enterprises, farms), improvement of the infrastructure of municipal and regional sewage draining and treatment, complex water protection measures, renewable energy utilisation projects and reducation on sustainable consumption. The following operation types are eligible for the implementation of the above:

- As part of the Individual Sewage Treatment National Implementation Programme, the sewage treatment of conurbations and settlements with a population equivalent of less than 2000 should be supported with a mixture of technical solutions and through preference for small sewage storage facilities that ensure nature-friendly sewage storage.
- Eligible activities include soil water protection, rainwater drainage and collection in settlements and surface drainage of rainwater for damage prevention.
- The elimination and prevention of damages by terrain-related danger sources (for example, high banks of the Danube) to the operation, physical infrastructures and public institutions of settlements should be enabled.
- In water base protection areas with regional importance, the protection of the quantity and quality of our waters is extremely important to prevent the further pollution of waters. In association with this principle, activities counterbalancing the risks of water bodies with a high hydro-morphology risk are eligible:

- Riverbed and flood area rehabilitation;
- For the protection of water quantity: water reservation, water replenishment and water back-routing, in accordance with the interventions of the National Agricultural and Rural Development Plan (Hungarian acronym: 'NAVT').
- Prevention of the further pollution of surface and underground waters (rehabilitation of mines no more uses, remediation of polluted areas, etc.).

North Hungary Operational Programme

Priority axes:

- Creating competitive local economy
- Strengthening tourist potential
- Settlement development
- Development of human community infrastructure
- Development of regional transport
- Professional support of the implementation of the operational programme (technical Assistance)

Infrastructural development of rural settlements supplementing the rural development program is a crucial point of the settlement development priority axis. Support may be given to settlements not involved in the development of urban settlements. When granting supports preference is given to small settlements of socially-economically disadvantaged areas and of areas that belong to prioritised tourist destinations. As part of the program of small settlements harmonised at micro-regional level, the intervention may support the activities described below. ESF type activities may produce their effect at several settlements.

Of physical investments support should be given to projects aimed at:

- Developing central dirt roads into roads with solid pavement, upgrading central roads; building pavements; for good cause, building separate bycicle paths;
- Providing natural sewage cleaning for settlements outside sewage management agglomerations with 2000 resident equivalent; and providing equipment to substitute public utility, with special focus on low capacity natural solutions for areas with karstic soil and small villages;
- Developing infrastructure that serves community transport;
- Developing energy saving public lighting;
- Development of infrastructure serving community purposes
- Risk prevention related development projects: water drainage investments at settlements (e.g., drainage of rainfall in central areas of settlements), especially at settlements on mountainous areas, lying beside water courses, linked to building shower reservoirs;

ESF type interventions up to max. 10% of the budget of projects to be supported, e.g.:

- Local information disseminating, attitude shaping, environmental awareness-raising actions;
- Community building; promoting general, voluntary training programs of the inhabitants;
- Arranging programs for the young, for spending free time;
- Promoting local employment initiatives directly related to infrastructural development projects, and residential area services that create new jobs (e.g., social economy)
- Promoting educational, training programs related to projects to be supported.

Within this scope, the active cooperation of non-state (non-governmental, ecclesiastical) actors, organisations can be usefully integrated into the complex settlement rehabilitation.

Central Transdanubia Operational Programme

Priority axes:

- Regional economic development
- Regional Tourism Development
- Integrated urban development in central transdanubia
- **Infrastructure development to reinforce local and regional cohesion**
- Technical assistance

Preservation of environmental assets, and enhancement of environmental safety

Within the framework of this Field of Action, the following items, outside the scope of national commitments, will be encouraged: development of wastewater disposal and treatment for settlements outside urban agglomerations and in micro-villaged areas (i.e. settlements with a resident equivalent [hereinafter RE] below 2000), including enhancement of relevant awareness, and encouragement of willingness to get homes connected up to public sewage systems; elimination and prevention of geological risks (i.e. landslip of natural water banks) threatening settlements, public institutions, and linear infrastructure installations; and integrated programmes based on water condition monitoring, and carried out within the framework of water-catchment area management efforts in compliance with Guidelines (EC) No. 2000/06 on Waters as approved by the EU Commission.

Indicative Types of Operation

- Develop wastewater disposal and treatment systems;
- Take measures to ensure stability of water banks susceptible to landslip;
- Reconstruct water systems of local and regional significance.

South Transdanubia Operational Programme

Priority axes:

- The creation of a competitive economy built upon the development of urban areas
- Strengthening tourism potential in the region
- Human public services and community settlement development
- ***Improving accessibility, and environmental Development***
- Financing the implementation of the south Transdanubia operational programme (technical assistance)

Developing wastewater management in small settlements

Developing wastewater management in **micro-village areas and small settlements** (settlements below 2000 resident equivalent) is a task of fundamental importance from the perspective of convergence and ensuring equality of opportunity, the emergence of tourism, the settling of venture capital, as well as the improvement of competitiveness. The introduction of stand-alone wastewater purification devices, as well as alternative - close-to nature - wastewater treatment solutions that can be established and maintained economically is also justified from the perspective of cost-efficiency, along with providing support for liquid waste (wastewater removed with sniffing trucks) treatment. Support can be provided for implementing wastewater treatment appropriate for natural and social characteristics, taking economic considerations into account, through the following operations:

- the construction of sewer systems in settlements, and the purification of wastewater collected with sewers at close-to-nature wastewater purification compounds above all else,
- the stand-alone treatment of settlement liquid waste (e.g. stand-alone wastewater depositing sub-facility, small stand-alone wastewater purification device, and stand-alone sealed wastewater basin).

4.4 Action Plans of the Regional Operational programmes

Every Operational Programme has an Action Plan for the next 2 years (2007-2008). Through these action plans, the regions sets out targets and objectives what to finance and to what extent int he near future that fullfil the objectives of the New Hungarian Development Plan and Regional Operational programmes.

The Environment and Energy Operational Programme (EEOP) includes different constructions and provisions to address the problems of waste water management in settlements beyond 2000 PE. However, solutions and programs for the management of waste water in case of settlements under 2000 PE are offered within the scope of the Regional Operational Programmes. The management of communal waste water produced in such settlements is an inevitable and necessary action concerning quality of life of people in the regions and state of environment of the settlements.

Beneficiaries

In every region, only municipalities or municipal associations are eligible for any kind of support on the action Plans.

Area of concern

Those settlements in the regions which are under 2000 PE.

Activities eligible for support in 2007-2008

Regional Action Plans	Activities to support
West Pannon	Establishment of environment friend waste water treatment and connected sewage network Implementation of traditional waste water treatment and connected sewage network Implementation of individual waste water disposal methods based on biological treatment methods Procurement of vehicles for transportation of waste water Combination of above mentioned
South Great Plain	Construction of sewage network Introduction of biological treatment Establishment of environment friend sewage treatment substituting public works Treatment and disposal of municipal liquid waste Implementation of sewage network
North Great Plain	Implementation of individual, environment friend waste water treatment methods Introduction of biological treatment Construction of capacities substituting public works Establishments for treatment of municipal liquid waste Implementation of waste water treatment network (if treatment and disposal of waste is possible)
North Hungary	Treatment methods and sewage network construction Capacity expansion of exisiting water plants Environment friend treatment methods and connected sewage network and establishments substituting public works Individual sewage disposal Combination of above mentioned Vehicles for transportation of sewage Establishment of treatment plants for municipal liquid waste
Central Transdanubia	Water treatment methods and construction of conecting sewage network Environment friend sewage treatment and concstruction of connecting network Individual sewage disposal and establishments Vehicles for transportation of sewage Combination of above mentioned
South Transdanubia	Implementation of environment friend and cost effective waste water treatment technologies Introduction of individual waste water treatment methods; tretmanet of municipal liquid waste Collection and transfer of municipal waste to existing water plant with free capacity

Financial background

West Pannon	
Aid intensity *	Max. 90 %
Amount of aid	Max. 400 000 Euro
Own contribution	Min. 10 %
Supprted projects in 2007	9
Supprted projects in 2008	10

South Great Plain	
Aid intensity *	85 %
Amount of aid	
minimum	40 000 Euro
maximum	2 000 000 Euro
Own contribution	
Own contribution in case of underdeveloped settlements	
Supported projects in 2007	
Expected amount of support	
Supprted projects in 2008	
Expected amount of support	

North Great Plain	
Aid intensity *	Max. 90 %
Aid intensity * in case of underdeveloped settlements	Max. 95 %
Amount of aid	
minimum	80 000 Euro
maximum	1 600 000 Euro
Own contribution	Min. 0 %
Supprted projects in 2007	3
Expected amount of support	n.a
Supprted projects in 2008	5
Expected amount of support	n.a

North Hungary	
Aid intensity *	90 %
Amount of aid	
Minimum	120 000 Euro
Maximum	1 600 000 Euro
Own contribution	
Own contribution in case of underdeveloped settlements	
Supported projects in 2007 and 2008	10
Expected amount of support	

Supported projects in 2008	
Expected amount of support	
Central Transdanubia	
Aid intensity *	Max. 85 %
Amount of aid	
Minimum	80 000 Euro
Maximum	2 000 000 Euro
Own contribution	
Own contribution in case of underdeveloped settlements	
Supprted projects in 2007	
Expected amount of support	
Supprted projects in 2008	
Expected amount of support	
South Transdanubia	
Aid intensity *	80 %
Amount of aid	
Minimum	40 000 Euro
Maximum	2 400 000 Euro
Own contribution	20 %
Own contribution in case of underdeveloped settlements	10 %
Supprted projects in 2007	0
Expected amount of support	0
Supprted projects in 2008	14
Expected amount of support	9 720 000 Euro

* Aid intensity: amount of aid applied for/eligible cost

Monitoring indicators of the action plans (targets)

West Pannon	
Population linked to the sewage network as a result of the developments	5000 people
Sewage treatment capacity	500 m^3/day
South Great Plain	
Population linked to modern sewage treatment systems	2000 inhabitants till 2008; 8000 till 2010
North Great Plain	
Number of environment friend sewage treatment plants	5 till 2010; 25 till 2015
North Hungary	
Population linked to modern sewage treatment	15000 till 2015
Central Transdanubia	
Number of implemented sewage treatment systems	13 till 2015
Number of implemented environment friend sewage treatment plants	4 till 2015
Number of traditional sewage systems	9 till 2015
Number of vehicles for the transportation of sludge	4 till 2015
South Transdanubia	
Population linked to modern sewage treatment	5000 till 2008; 15000 till 2010; 55000 till 2015

The implementation of above mentioned programmes is the only factor that could ensure the start of development and improvement within such area.

Call for proposals are being prepared, they in the final phase that could be followed by implementation of the beneficiaries.

Conclusions

Conclusions

In the imminent future, vast efforts will be needed in many European countries to fulfill the targets of the Urban Wastewater Treatment Directive (91/271/EEC) as well as the Water Framework Directive (2000/60/EC). Improvements in wastewater treatment will need to be implemented especially in rural areas and small villages. The best practices and solutions are not easy to define; the climatic, geographic and economical factors all contribute to creating a complicated situation.

In Finland, approximately one fifth of the population lives beyond the reach of the municipal sewer networks. A significant proportion of these on-site wastewater treatment systems will require renovation during the coming years if they are to meet the requirements given in the Government Decree on Treating Domestic Wastewaters in Areas Outside Sewer Networks (542/2003). New technological solutions have appeared on the market, but still the purification results are variable. The proper use and maintence of the treatment systems are the key in order to reach the best results.

In the UK, the majority of households, approximately 98 %, are connected to the mains sewerage network. For the remaining 2 %, it appears that septic tanks are the most popular option followed by private sewage treatment works. In the near future, many private sewers will need renovation, because they are in a state of severe disrepair. More effort needs to be concentrated on collating existing data and centralisation of information regarding the whereabouts and details of private sewage tratement schemes. Special focus in the UK is on the development of tertiary treatment, primarily phosphorus stripping using chemical precipitation.

In Hungary, the proportion of households connected to the sewerage system was only 56 % by the end of the year 2002. The most urgent need for development is in rural areas and small settlements areas (smaller than 2000 person equivalent). New products e.g. package plants, have appeared on the Hungarian market, but they are often far too expensive solutions. Another option is the so called near-natural wastewater purification systems, e.g. pond systems, tree plantation systems and built hydrophyte systems. However the climatic conditions during winter restrict the use of these systems. The New Hungarian Development Plan includes Environment and Energy Operational Programme, which in turn includes also plans for wastewater treatment.

Savonia University of Applied Sciences

Rural Wastewater Treatment in Finland, the United Kingdom and Hungary

Kuva Sherry Wil

This summary consists of three country-specific parts, it provides an overview about rural wastewater treatment in Finland, the United Kingdom and Hungary. The report from Finland has been compiled in co-operation with Savonia University of Applied Sciences and the City of Kuopio. The University of Brighton has prepared the UK part and the University of Debrecen is responsible for the Hungarian part.

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