SUSTAINABLE SANITATION IN CENTRAL AND EASTERN EUROPE

– addressing the needs of small and medium-size settlements

Edited by

Igor Bodík and Peter Ridderstolpe

Global Water Partnership contribution to International Year of Sanitation 2008

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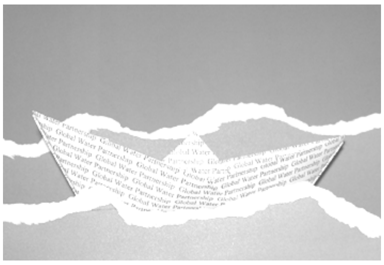
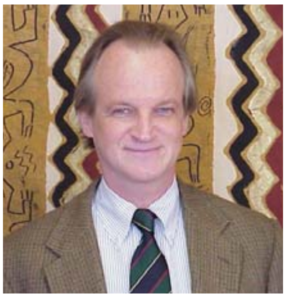


Foreword

Roberto Lenton



At the World Summit on Sustainable Development in 2002, the international community called on countries to prepare Integrated Water Resource Management (IWRM) and Water Efficiency Plans by 2005. Since then, the Global Water Partnership has offered substantial support to countries that are trying to meet that call. With the designation of 2008 as the International Year of Sanitation, GWP has an outstanding opportunity to support national efforts to fulfill another goal set by the same Summit – to halve by 2015 the proportion of people who do not have access to basic sanitation.

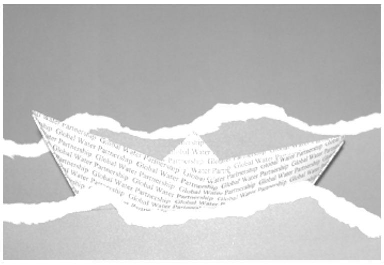
I am therefore genuinely delighted to write this foreword for the new publication by the GWP's Central and Eastern Europe (CEE) Regional Water Partnership, "*Sustainable Sanitation in the Central and Eastern European Countries – addressing the needs of small and medium size settlements*." This book recognizes that sanitation is the foundation of human health, dignity and development. And it calls attention to a serious challenge – how to radically increase access to basic sanitation in ways that reflect the principles of economic efficiency, social equity and environmental sustainability – the 3 E's – on which the Integrated Water Resources Management approach is built.

An important implication of this book is the need to ensure that sanitation has a proper place in the development of IWRM and water efficiency plans, as called for in the Johannesburg Plan of Implementation. Using its experience in facilitating the preparation of IWRM Plans in several countries, GWP is well positioned to demonstrate to our partners the strong inter-relationships among sanitation and water resources management. Incorporating sanitation objectives into ongoing planning efforts could accelerate progress towards meeting the Millennium Development Goal target on sanitation and bring us closer to attaining a proper balance among efficiency, equity and environmental sustainability considerations.

"*Sustainable Sanitation in the Central and Eastern European Countries - addressing the needs of small and medium size settlements*," provides an excellent overview of the state of sanitation in CEE countries, and offers sustainable sanitation solutions and a set of cases illustrating workable sanitation systems that could be scaled up across the region. The sustainable sanitation initiative taken by GWP CEE reflects the value added of a partnership living up to its mission to support countries in the sustainable management of their water resources. In this region, which has had a decade of partnership experience in transition and is now entering the European Union, lack of sanitation has been found to limit efforts to improve equity, well-being, water quality and economic development. The GWP CEE study has identified a gap of 20-40% of rural populations without sanitation policies because, in line with priorities agreed upon with the European Commission, the sanitation programs of many governments in the region thus far do not deal with settlements up to 2000 persons.

The GWP CEE initiative to prepare this book is an excellent example of international cooperation, in which CEE experts together with their Swedish and German colleagues have addressed the sanitation issue from an IWRM perspective. The initiative has also encouraged discussion within the GWP Network about the need for more integration of sanitation in water resources development, planning and management by suggesting practical ways forward. Importantly, the book is also well timed to contribute to the International Year of Sanitation 2008, when we will have a unique opportunity to raise awareness and galvanize political will, especially at the national level. This is crucial, for it is national governments, working with communities, municipalities and international actors, who ultimately must expand sanitation services. And as this book demonstrates, GWP has an important role to play.

Roberto Lenton
July 2007



Chapter 1

Time for Sustainable Sanitation

Danijel Vrhovšek

In 2004 about 3.5 billion people worldwide had access to piped water supply through house connections. Another 1.3 billion had access to safe water through other means than house connections, including standpipes, protected springs and protected wells. However, more than 1 billion people did not have access to safe water, meaning that they had to revert to unprotected wells or springs, canals, lakes or rivers to get water.

In 2000 all UN member states signed the United Nations Millennium Declaration (UNMD) with eight Millennium Development Goals (MDGs). Goal number seven commits the states to ensure environmental sustainability by reducing the proportion of people without sustainable access to safe drinking water by half by 2015. This commitment was expressed again at the World Summit on Sustainable Development in Johannesburg in 2002, where basic sanitation was added to the above mentioned Millennium Development Goal, the reason being that 3 billion people lack safe sanitation services.

Actually, in 2007, the situation regarding drinking water in developing countries is even worse than it was a few years ago, mostly because of pollution, irrigation, lack of money, wars and progressive climate change. The World Health Organization has defined around 20 liters of water per capita per day as the minimum amount for life needs – although this amount still implies high health concerns – and 100 liters per capita per day as the optimal access, associated with low health concerns. Nevertheless, an adequate amount of water of adequate quality is essential for public health and hygiene. In addition to human needs for water, non-domesticated plants, animals, and other organisms need water as well.

The question is what to do in a situation where there is less and less water for all of these needs, not to mention the growing human population, that year by year demand more and more water?

One possible answer is to be stricter about wastewater treatment, where purified water is used for recycling purposes. Over the past few decades, the "conventional sanitation" approach has been severely criticised and consequently, many definitions, concepts and characteristics have been proposed for alternative "sustainable sanitation". In general sustainable sanitation is a more holistic approach towards environmentally and economically sound sanitation. It includes wastewater disposal and treatment, vector control and other disease-prevention activities. Sustainable sanitation is based on the three pillars of sustainability – environmental, economic and social. The environmental pillar is, in this case, the application of recycling principles protecting the local environment. The key objective of this approach is a new sustainable philosophy that uses the waste as a resource. The approach is based on the implementation of the material-flow-oriented recycling process as a holistic alternative to conventional solutions. Under ideal conditions sustainable sanitation systems enable the complete recovery of all nutrients from faeces, urine and grey water to the benefit of agriculture, and the minimization of water pollution, while at the same time ensuring that water is used economically and reused to the greatest possible extent, particularly for sustainable irrigation purposes.

The GWP Central and Eastern Europe (GWP-CEE) book on Sustainable Sanitation that you read now, is an important step into a more sustainable "mankind" future. It provides data about the current status of the water supply and sanitation in the GWP-CEE countries, information on sustainable sanitation for small and medium size settlements in CEE, a few case studies from European countries such as Hungary, Ukraine and Slovenia, as well general information on the sustainable sanitation situation in Germany and Sweden, and an overview of legislation on sustainable sanitation in EU and in some CEE countries.

The study focuses on eleven countries of Central and Eastern European GWP region which represents approximately 16% of continent territory and where about 20% of the European population lives. In the territory reaching from the Baltic Sea to the Adriatic and Black Seas there are different natural, social and economic conditions, as well different approaches to water management. An important element in the population and demographic structure of the inhabitants of the CEE countries is the relatively high proportion of inhabitants living in the rural areas compared to the countries of Western Europe. Of the total number of settlements in CEE countries, 91.4 % settlements have less than 2000 inhabitants, accounting for 20% of the CEE population. With the main focus of European Union legislation focused on solving the wastewater problems on agglomerations with more than 2000 inhabitants by 2015, it seems that villages with less than 2000 inhabitants are being ignored by decision makers and water managers. On the other hand, the communities in these rural areas are often economically weak thus less developed in the terms of infrastructure. That is why this study primarily focuses on these settlements, where sustainable sanitation approaches requires a lower financial investment compared to the conventional, high-tech, expensive alternatives. For most of these settlements sustainable sanitation is the most relevant concept to implement for providing adequate water supplies and sanitation to achieve the MDGs by 2015.

The percentage of the population in the CEE countries connected to central water supply systems ranges from 53.5% to 98.8%, depending on the country, whereas the percentage of the population connected with Waste Water Treatment Plants (WWTPs) varies from 30% to 80%. The data from individual countries show that the target for all countries ranges from 75–90% of their populations to become connected to sewerage and treatment systems. As it has been mentioned already, according to EU Directives the construction of a WWTP for settlements of less than 2000 inhabitants is not mandatory. But the countries are obliged, according to EU Water Framework Directive (EU WFD), to achieve the "good status of all the waters" in their territories. This leaves a gap of 10–15 % of the population (corresponding to about 20 million rural inhabitants) that will remain without proper sanitation systems after 2015. From the point of view of existing wastewater treatment systems the dominant process in small settlements in the CEE countries is the use of cesspools. This is a very imperfect process of wastewater treatment because it is only “accumulation” or “pre-treatment” of wastewater, not a full-value treatment process. The second most commonly used process of wastewater treatment in small and rural settlements in the region is biological treatment, an activation process. Regarding the WWTPs the CEE countries will face problems with disposal of wastewater sludge, therefore ecologically safe methods for sludge processing must be exploited with the aim of minimizing the sludge quantity and maximizing the recycling of sludge, without compromising human health safety. Natural systems for wastewater treatment are to some extent used in the region. In the CEE countries the most wide-spread natural processes are constructed wetlands, sand-soil-reed filters, macrophyte filters, lagoons and wastewater irrigation systems.

In some European countries so called ‘sustainable sanitation systems’ have already been developed and introduced. These systems include source separation of domestic wastewater into different fractions such as grey water, urine and faeces for the reuse of natural resources (nutrients, water and heat). Water sanitation is by definition, hygienic disposal or recycling of wastewater, as well as the policy and practice of protecting health through hygienic measures. “Sustainable Sanitation” as a new sanitation concept includes the environmental, social and economical points of view, as well as all three primary functions of sanitation and wastewater treatment: the protection of public health, recycling of nutrients and protection against environmental degradation. Wastewater is known as the main pathway for spreading diseases in the world, so barriers must be used to prevent faecal exposure. Sustainable sanitation systems have such solutions. Use of artificial mineral fertilisers has made many farmers uninterested in nutrient recycling from toilet waste which, if not treated properly, became an environmental problem. To make both wastewater treatment and agriculture sustainable in the long-term, the nutrients in toilet waste, as well recycled water, have to be reused mostly in agriculture. It is also well known that untreated or poorly treated wastewater can cause environmental degradation by eutrophication, increased salinity of soils and so on, which is not a solution in the case of sustainable sanitation. An important reason for choosing a system that fulfils treatment objectives all year round including varying loads is, in most cases, the low construction and operation costs in comparison to conventional sanitation approaches. Although treatment in conventional wastewater treatment plants seems very different from natural treatment methods (stabilization ponds, precipitation ponds, constructed wetlands, etc.), they are all based on the same physical, chemical and biological processes. To get a well-functioning sanitation system, the selected environmental system has to be modified to suit local conditions and needs.

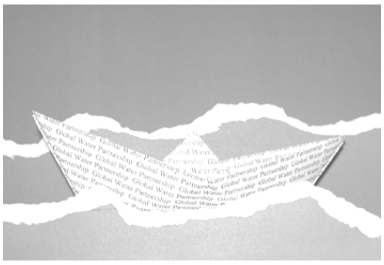
To show some practical experience a few case studies have been presented in more detail in Chapter 4: Dry urine-diverting school toilets in villages in Ukraine; Wastewater irrigation of poplar plantation – a sustainable solution for a small settlement without sewerage system – in Hungary; and Constructed Wetland Sveti Tomaž in Slovenia. In the same chapter, two Western European countries describe their experience: Sustainable Sanitation and Wastewater management in Sweden; a cross section overview and Ecological Sanitation in Germany high-, medium and low-tech development projects.

From the point of view of legislation, the main conclusion is that EU law does not make it obligatory for member states to build sewage systems that separate urine and/or faeces. There are legal obstacles to the use of sewage sludge but the question is, should pure fractions of urine and/or faeces be included in “sludge” or not? Since the EU member states have to adopt the EU directives in their national legislation, all 11 countries have carried out the processes in relation to the EU water legislation.

Sustainable sanitation systems have many perspectives. Organic flows are not taken into consideration in the majority of current “conventional” practices. However, in a fully sustainable world all organic flows must cycle. Sustainable sanitation systems are very effective since they have low energy consumption and, what is more, some even produce new sources of energy (wood biomass or biogas) while others are CO_2 sinks, CO_2 being an important greenhouse gas. Due to the present unpredictable climate changes it is important that sustainable sanitation systems can act as water retention reservoirs. And, as a new biotope, they can function as a refuge for some organisms.

Some estimates put the world price tag on providing universal sanitation at $68 billion. This money might provide coverage but without a careful consideration of how it is spent, solving one set of problems may lead to another.

Sustainable sanitation systems are culturally appropriate, locally responsible, and functionally sustainable. Bringing these efforts to a wider scale will require engineering and financial changes in infrastructure that supports sewerage. This infrastructure will need to be replaced with one that supports ecological innovations in waste treatment. Banishing practices that threaten to harm human health or the environment and rebuilding sanitation infrastructure from a sustainability orientation are both a challenge. Our common challenge.



Chapter 2

Current Status of Water Supply and Sanitation in the GWP CEE countries

Igor Bodík

INTRODUCTION

After more than fifty years of economic mismanagement and environmental neglect in the post-communistic Central and Eastern Europe (CEE) countries, these countries have started to correct the effects of the previous rulers' policy in this field. As far as the environment and water pollution are concerned, the heritage from the past regime is serious. It is characterized by a high level of water contamination, the co-existence of problems caused by traditional pollutants as well as point and non-point sources. Additional difficulties are caused by the past contamination of soil, sediment and groundwater, which presents the issue of costly and slow rehabilitation. In the European context, the human dimension of insufficient sanitation systems makes the situation more urgent to solve in CEE and the Eastern Europe, Caucasus and Central Asia (EECCA) countries. Access to improper or no sanitation at all affects the poorest and most vulnerable part of the population.

In spite of the above-mentioned features, water pollution problems of the CEE countries should not be considered unique in a technical sense. Similar situations existed in the industrialized regions of the West about thirty years ago (e.g., the Ruhr and Rhine Rivers in Germany), and it is evident that tools and technologies are available for the cleaning up. The uniqueness stems from the coincidence of the need to handle the serious issues mentioned above and the very specific political, economic, and social conditions that exist in this region.

The main objective of this chapter is to analyze the recent status of wastewater management in the CEE countries with the focus on the sewerage and municipal wastewater treatment in this region.

WASTEWATER MANAGEMENT IN CEE COUNTRIES

Basic geographical and demographical characteristics of the CEE countries

Altogether there are eleven[1] European countries located in the GWP's Central and Eastern European region – see Figure 2.1. Some basic geographical and economical indicators for these countries are compiled in Table 2.1.

From the data presented Figure 2.1 and Table 2.1 it is evident, that the CEE countries represent a relatively important part of the Europe. From the total area of Europe's continent (10.5 million square kilometres) the CEE countries encompass around 16% of the territory and around 20% of Europe's population live in the CEE countries. In the family of CEE countries there are small countries (Slovenia, the Baltic countries) and big countries (from the territorial and population points of view) like Ukraine, Poland and Romania. Ukraine is the biggest country in the family of CEE from the point of view of the territorial area (603,000 km^2) and the number of inhabitants (47.7 million). The smallest CEE country is Slovenia (20,300 km^2) while the smallest number of inhabitants live in Estonia (1.3 million). From a hydrographic point of view, the area encompassed by the CEE countries is divided into the basin of five seas:

- The Black Sea – predominant part of the CEE area belongs to the basin of the Black Sea (whole area of Hungary, Romania and Ukraine, a predominant part of Slovakia and Slovenia, a minor part of the Czech Republic and Bulgaria, and a negligible part of Poland);
- The Baltic Sea – whole area of Lithuania, Latvia and Estonia, a predominant part of Poland, minor parts of the Czech Republic and Ukraine, and a negligible part of Slovakia;
- The North Sea – important part of the Czech Republic;
- The Aegean Sea – important part of Bulgaria;
- The Adriatic Sea – small part of Slovenia.

The CEE countries are spreading not only in Central and Eastern Europe (as stated in their "official" name) but they also create the important part of the Northern and Southern Europe. Coastal and continental countries, plain and mountainous countries, more or less wealthy, industrialised and agricultural, and countries with mild and northern climates belong to this group. Accordingly, the climatic, geographical, weather, thermal, hydrological, social, economic and other conditions in these countries is relatively different and hence the water management requirements will be different.

An important element in the population and demographic structure of the inhabitants of CEE countries is the relatively high proportion of inhabitants living in rural areas compared to the countries in Western Europe. The proportion of inhabitants living in rural settlements varies from 25% (Czech Republic) to 50.5% (Slovenia), and the total number of inhabitants living in rural settlements is estimated to be about 56 million (37.3%). Of the total number of settlements (142,645) in CEE countries, 130,347 settlements (91.4%) have less than 2000 inhabitants. In this aspect relatively large differences can be observed between countries; for example, the proportion of settlements containing 2000 or less people in Hungary is 74.7%, while in Poland, Slovenia, Latvia and Lithuania it is over 95%. It is surprising that in Ukraine only around 5% of the country's' population live in the settlements with less than 2000 inhabitants. As a consequence, "small settlements" in Ukraine are those containing 20,000 inhabitants or less and represent 30% of the total population of Ukraine.

[1] Moldova is the 12th country of GWP CEE, joining in October 2006.

Figure 2.1. Geographical description of the Central and Eastern European countries location.

The settlements with less that 2000 inhabitants are an important part of the demographics of the CEE countries, representing 20.0% of the overall number of persons living in CEE countries. In Slovenia, 51.5% of the population live in such settlements (the highest in CEE) while the lowest levels are found in Romania (9.2%) and Ukraine (4.8%), shown in Figure 2.2.

The population living in settlements smaller than 2000 inhabitants play an important role in water management. The European Directive 271/91/EEC on Urban Wastewater Treatment obliges the member states to build up and operate the biological stage of waste water treatment in all agglomerations with over 2000 inhabitants by 2015. As the implementation of this obligation is subsidized from European funds in all CEE countries, the countries are all making considerable efforts to fulfil the Directive.

Table 2.1. Basic geographical and demographical parameters in the CEE countries (year 2005)

Country		Country territory	Present population	Number of settlements	Number of settlements with < 2000 inhabitants	Population in settlements with < 2000 inhabitants	
		1000 km^2	Mil.	-	-	Mil.	%
Bulgaria	BGR	111,0	7,7	5332	4941	1,88	24,4
Czech Rep.	CZE	78,9	10,2	6249	5619	2,65	26,0
Estonia	EST	45,0	1,3	4700	4000	0,34	26,2
Hungary	HUN	93,0	10,1	3145	2348	1,71	16,9
Latvia	LVA	65,0	2,3	6300	6200	0,52	22,6
Lithuania	LTU	65,0	3,4	22153	21800	1,17	34,4
Poland	POL	312,7	38,2	40000	39000	14,70	38,5
Romania	ROU	237,5	21,7	16043	13092	1,99	9,2
Slovakia	SVK	49,0	5,4	2891	2512	1,65	30,6
Slovenia	SVN	20,3	2,0	5928	5835	1,03	51,5
Ukraine	UKR	603,7	47,7	29904	4300	2,3	4,8
Total	**CEE**	**1681,1**	**150,0**	**142645**	**109647**	**29,94**	**20,0**

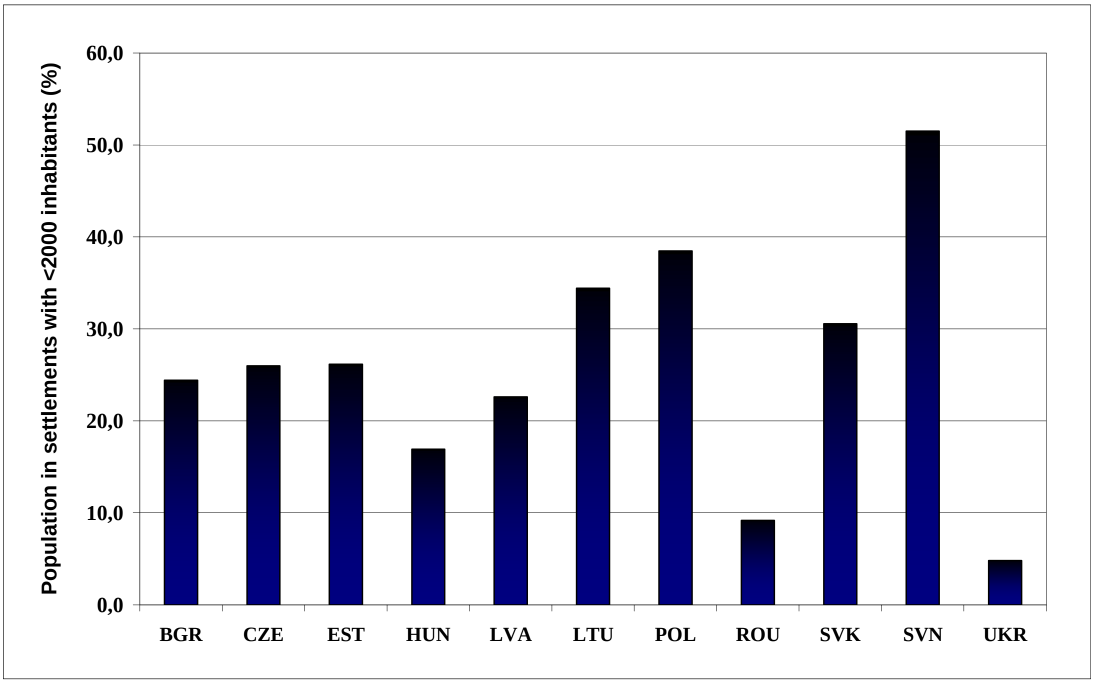


Figure 2.2. The percentage of the national population living in settlements with less than 2000 inhabitants in individual CEE countries.

The proportion of inhabitants living in small settlements with less than 2000 inhabitants seems to lie outside of the concern of the decision makers and water managers because of the priorities settled and solved by the countries. As shown in the data presented, the population living in the settlements with less than 2000 inhabitants form an important part of the CEE population. The population in rural areas is often economically weak, and the rural regions are less developed and lack the possibility to get the important economical support for the development of water and sanitation infrastructure. Based on the potential of this impact on water quality of European waters and human well-fare, it is essential to consider the development of rural water and sanitation systems as an urgent necessity.

Basic economical characteristics of the CEE countries

According to the data shown in the Figure 2.3 the CEE countries can be divided into three groups from the economic power point of view: the "wealthy countries" (Czech Republic, Slovenia) with a GDP per capita of over 70% of the EU-25 average, the "medium wealthy countries" (Estonia, Hungary, Latvia, Lithuania, Poland and Slovakia) with range of 45–70% and the "poorer countries" (Bulgaria, Romania and Ukraine) with a GDP lower than 45% of the EU-25 average. Common calculated value of GDP per capita in the CEE countries represents 41.0% of the EU-25 average.

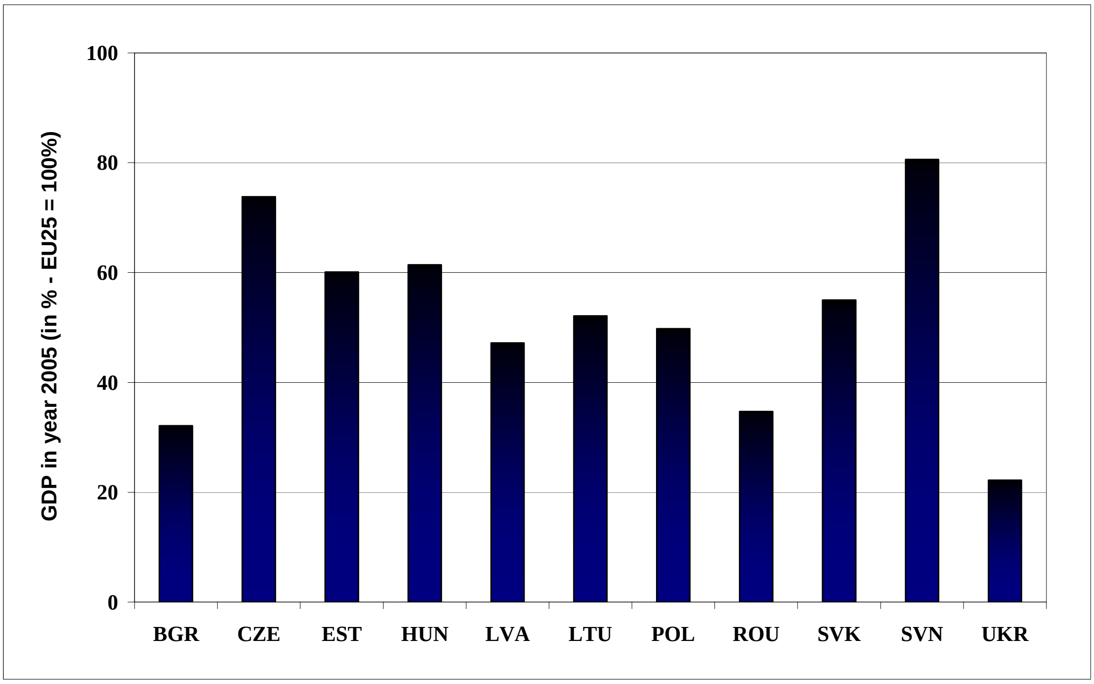


Figure 2.3. GDP per head in CEE countries (data 2005 – EU-25 = 100%)

The GDP per capita (as purchasing power parity) varied in the 11 CEE countries between Euro 4,480 (Ukraine) and Euro 16 300 (Slovenia), that means by factor of about 3.6. The economic status of the all CEE countries together is an annual per capita GDP of Euro 8,300. From the point of view of economic power of inhabitants the CEE countries represent the poorest part of Europe but from the point of view of economic development, CEE countries represent the most dynamic and developing part of Europe. The present situation with low labour costs, increased investments and a developing infrastructure makes the CEE region attractive from an economic perspective.

All above reported geographical, demographic and economic parameters are required to understand and define the problems of water resources management in the region *en bloc* and also within each of the CEE countries. The demand for improved quality of drinking water, the status of sewerage systems, the character, quality and quantity of wastewater treatment plants are key issues of water resources management in the CEE countries in their efforts to comply with the EU water legislation.

Drinking water supply

There are many criteria describing the current situation of the drinking water supply in the CEE countries. In Table 2.2 some important drinking water supply parameters of CEE countries are selected. One of the often used parameters that show the degree of development of water management in a given country is the connection of inhabitants to the public drinking water network. This value represents the ratio of inhabitants in the country that are supplied with the qualitative drinking water from public water sources (drinking water treatment.) The rest of the inhabitants are usually supplied from local water sources (private wells). However, the quality of the water is not controlled by governmental bodies and often can exceed the permitted qualitative parameters.

The connection of inhabitants of CEE countries to public water supplies is relatively high and it can range above 75%. The exceptions are Lithuania and Romania which have lower number of connections to the public water supply. The proportion of the population connected to the central water supply systems ranges from 53.5% for Romania to 98.8% for Bulgaria (the figure for Bulgaria is very surprising as this is comparable with many of the highly developed countries in Western Europe such as Denmark, Germany and others). Connection values above 60% indicate that mostly a country's urban population is supplied by central water systems. Values above 80% suggest that a predominant part of rural inhabitants are also connected to the public water supply and only a small part of inhabitants living in de-centralised areas have no access to public water supplies.

Domestic water consumption is restrictively defined as the quantity of water which is actually used by private households and which is metered and has to be paid for. The domestic water consumption ranges from 74 l/cap.d in Lithuania, which is extremely low consumption, to 250–320 l/cap.d in Romania and Ukraine, which is extremely high consumption and probably due to small private agricultural activities, irrational consumption, high water losses, lack of water consumption metering, and more. The remaining countries have comparable values of water consumption lying between 90–150 l/cap.d. A notable difference in water consumption lies between urban and rural areas. Technical equipment of residences is usually higher in urban than in rural areas, resulting in higher consumption of water from the public water supply net. On the other hand, rural inhabitants usually use other water sources (private wells) where water consumption is not paid for or controlled.

In general, a dramatic decrease of total water demand and domestic water consumption has been observed over the last ten years in all CEE post-socialist countries (mainly as a result of privatization of water companies and increasing water costs). This fact is exemplified by water consumption in households in the Slovak Republic (Figure 2.4) and increasing water prices in the Czech Republic during the years of 1993–2005 (Figure 2.5). The water price in the individual CEE countries varies from Euro 0.15/m^3 in Ukraine up to Euro 2.00/m^3 in Romania. It can be expected that the water price in CEE countries will increase in forthcoming years and will probably reach the same price as in the richer parts of Europe (Euro 3–4/m^3). Although water consumption has shown a significant decrease during the last period (Figure 2.4) a long-term increase in the price of water is expected in the CEE countries. A decline in the water consumption can be expected mainly in rural areas.

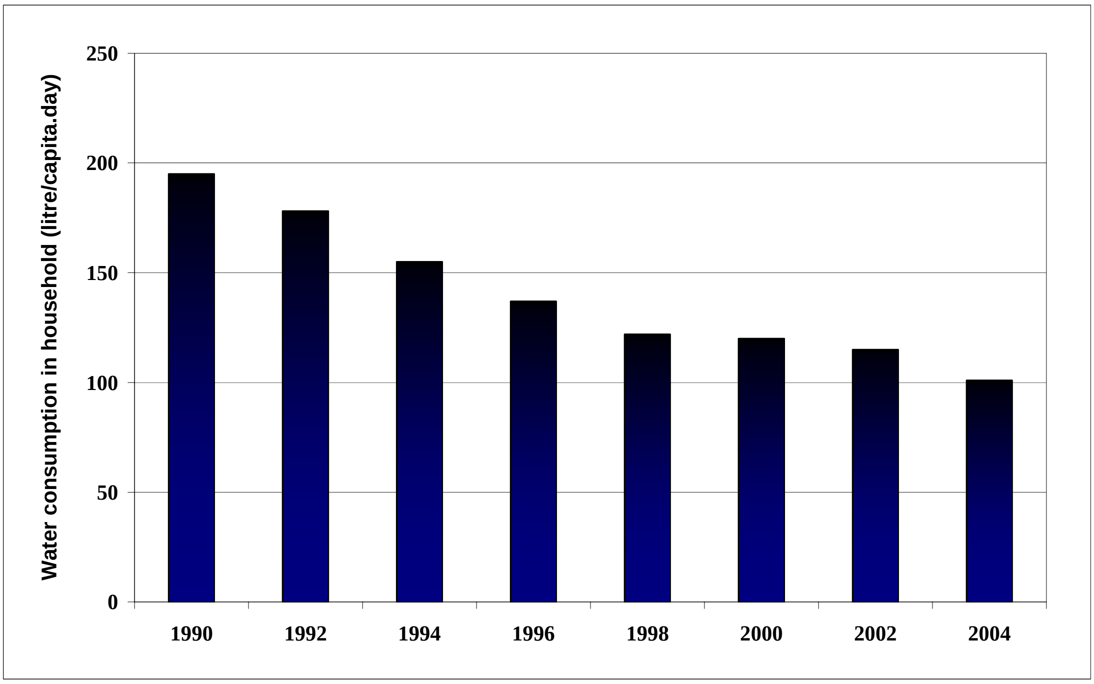


Figure 2.4. The development of domestic water consumption in the Slovak Republic.

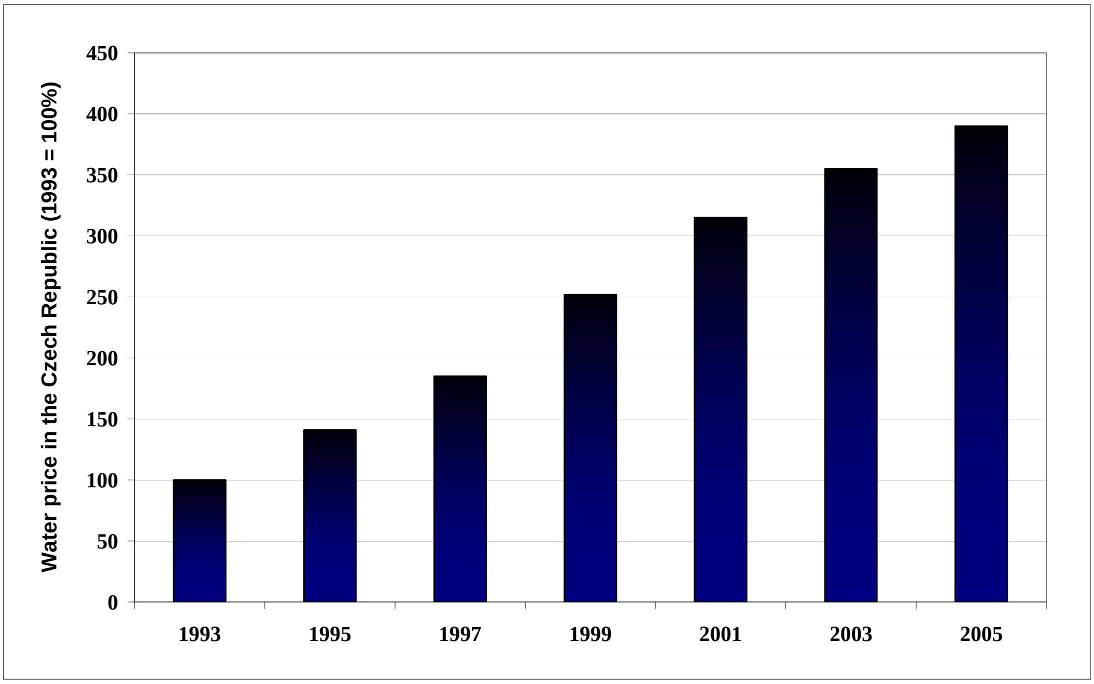


Figure 2.5. The development of water price in the Czech Republic in 1993–2005.

Table 2.2. The basic characteristics of water supply in the CEE countries.

	BGR	CZE	EST	HUN	LVA	LTU	POL	ROU	SVK	SVN	UKR
Population connected to central water supply (%)	98,8	91,6	77,0	93,0	75,0	66,0	85,4	53,5	85,3	92,0	70,0
Domestic water consumption (l/cap.d)	94	103	100	151	50-150	74	103	80-250	95	146	60-320
Water price – supply + treatment (Euro/m^3)	0,62	1,40	1,50	2,46	1,05	1,08	1,15	2,00	1,35	1,72	0,15

Sewerage and wastewater treatment systems in small settlements

Connection of inhabitants with the sewerage systems and WWTPs is an indicator of the water management quality of a country. The connection percentage in the CEE countries is relatively low in comparison with developed countries of Western Europe. This dates back to the long-term neglected development of infrastructure construction during the communist era in all CEE countries. The proportion of the population connected to central sewerage systems with WWTPs varies from 30% (Romania) to 80% (Czech Republic). The data provided does not always show the real status of WWTP development, e.g., in Slovenia a relatively high percentage of wastewater (ca 40%) is treated only by a mechanical stage and the quality of treated wastewater is correspondingly low.

As a consequence of the economic problems following the downfall of communist regimes, the development of sewerage infrastructure grew slowly. This lack of action was caused by the financial difficulties experienced during the transition into new economic structures and processes, obscure situations of privatization of sewerage systems, and more. However, later all CEE countries (with the exception of Ukraine) significantly developed their sewerage and treatment systems and they will continue to develop, thanks mostly to the support provided through the European accession funds (PHARE, ISPA, Cohesion fund and others).

From the data given in Figure 2.6, it is clear that in all CEE countries (except Bulgaria, Romania and Ukraine) almost all the urban population and a part of the rural population are connected to sewerage systems. From the point of view of future development of water management systems the data from individual countries shows the target for all countries to connect around 75–90% of population to sewerage and treatment systems. Besides forming settlement agglomerations – that is, connecting small settlements to wastewater treatment systems of bigger towns or joining small settlements to one joint WWTP – this development will have an important influence on the achievement of given targets in rural areas.

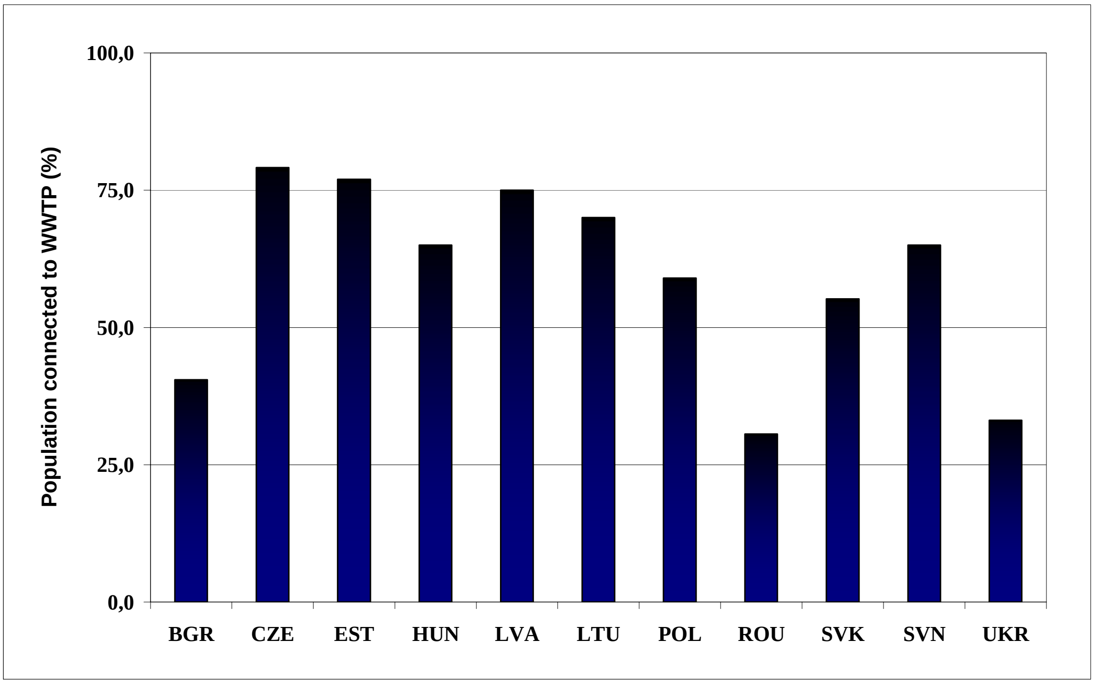


Figure 2.6. The share of inhabitants connected to public sewerage system with WWTP in the CEE countries.

The proportion of the population that lives in rural areas in the CEE countries is relatively high (Figure 2.2). This provides the rationale to find appropriate waste water treatment technologies for this part of the population. Basically, three alternatives for connection of rural population to sewerage and wastewater treatment systems can be considered:

1. Connection of small settlements to the wastewater treatment systems of big cities. In the case that the distance of the settlement to the nearest large WWTP is not very far (or that suitable geographical conditions exist) there is an assumption that connection of the small settlements to the given agglomeration should be made. Today this alternative is practiced in the Czech Republic and Slovakia, with reconstruction and upgrading of central WWTPs for additional rural settlements. Water companies prefer centralised approaches to the WWTP operation with many satellite settlements over the operation of many small independent WWTPs for many small settlements. From the point of view of investment costs these constructions are expensive (1 km of sewage pipes costs around Euro 250,000), which today "fortunately" are paid with EU funds.
2. Joining of several small settlements to one joint sewerage and wastewater treatment system. Again, the economic assessment of all aspects plays an important role. This alternative of construction approach for small and rural locations is used less in the CEE countries than the previous one.
3. Construction of individual WWTPs for every small settlement is quite frequent in the CEE countries. Nevertheless the construction of a WWTP for settlements with less than 2000 inhabitants is not mandatory according any EU Directive. It is usually the initiative of the major or local municipality council. To this comes the fact that CEE countries often support and subsidise the construction of small WWTPs, without serious consideration of the fact that amortisation (over several

decades), operation and maintenance costs will be financed by the "poor" water users.

Identified Gaps in Rural Sanitation
According the results of questionnaires for this study, approximately 150 million inhabitants live in the CEE countries of which 30 million, or 20%, live in rural settlements with less than 2000 inhabitants. Of this rural population, about 3.5 million persons are connected to big town WWTP systems and about 1.5 million are connected to small municipal WWTPs. The remaining 25 million rural people in the CEE countries are not connected to centralized waste water treatment systems. The perspective until 2015 is that 75–90% of the total CEE population will become connected to the centralized systems of sewerage and wastewater treatment. This leaves a gap of 10–15%, corresponding to about 20 million rural inhabitants, who will remain without any proper sanitation systems, that would meet any environmentally or socially acceptable standards after 2015!

Cesspools
From the point of view of existing wastewater treatment systems the dominant process in small settlements in CEE countries is the use of cesspools. This is a very imperfect process of wastewater treatment (it is only accumulation or pre-treatment of wastewater, not a full-value treatment process). It is worth noting that today around 75% of rural population in the CEE countries uses this type of inferior treatment (Figure 2.7). In some areas of Central Europe cesspools serve as the pre-stage of wastewater treatment before the final discharge into the recipient system. These cesspools very often overflow and they do not fulfil the basic legislative requirements for wastewater treatment. Usually mostly old houses (20 years and older) are equipped with them, and it is very complicated (by legislative and technical ways) to achieve improvements.

Biological Treatment
The second most commonly used process of wastewater treatment in small and rural settlements is biological treatment – an activation process. The activated sludge process is a wastewater treatment method in which the carbonaceous organic matter of wastewater provides an energy source for the production of new cells for a mixed population of microorganisms in an aquatic aerobic environment. The microbes convert carbon into cell tissue and oxidized end products that include carbon dioxide and water. Activation is mostly used in the rural areas of Estonia and Lithuania. This process is more technically demanding but when correctly operated it usually fulfils all treatment requirements. Activation process in rural conditions is usually represented by a small WWTP (more than 50 connected inhabitants) or by a household WWTP (5–50 connected inhabitants). The household WWTPs have been growing in popularity in rural areas of the CEE countries during this period. For example, in the Czech Republic about 20,000 household WWTPs have been constructed during the last 10 years, connecting 100,000 inhabitants (1.0% of population of the Czech Republic).

Natural Wastewater Treatment Systems
Natural systems for wastewater treatment are used to some extent in the CEE region. On one hand there are countries with the long-term good experience with this type of processes, e.g., Estonia, the Czech Republic, Hungary, Poland and Slovenia (Figure 2.8). On the other hand there are countries with no experience of using natural wastewater treatment systems, e.g., Slovakia, and Bulgaria. In the CEE countries the most common natural processes are constructed wetlands, sand-soil-reed filters, macrophyte filters, lagoons and wastewater irrigation systems.

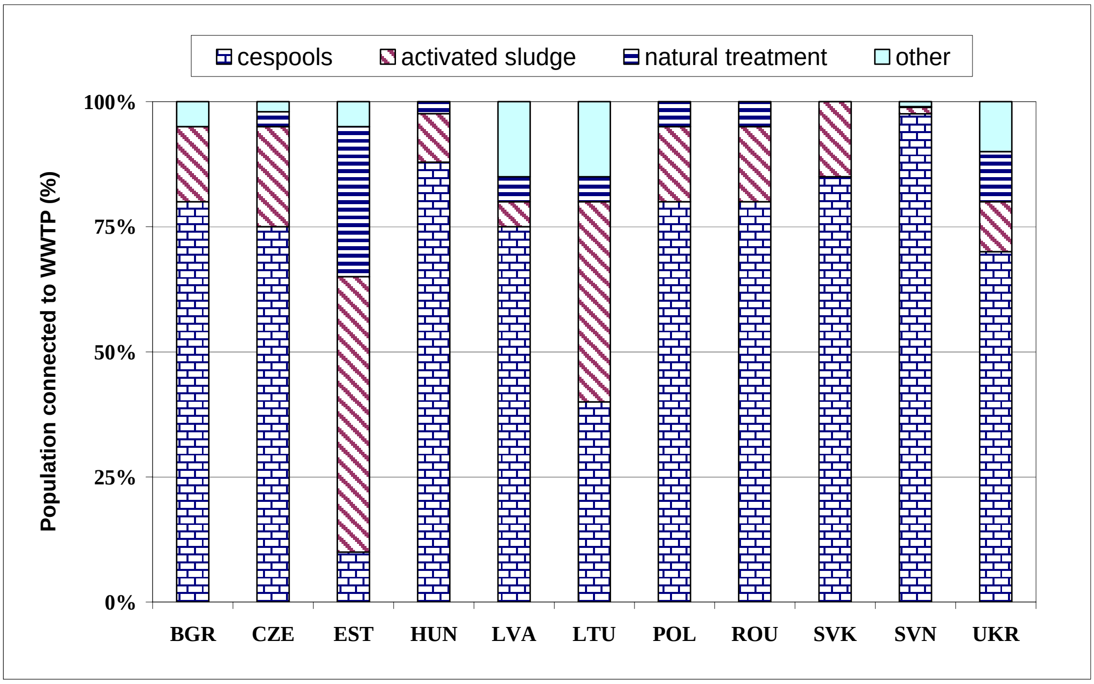


Figure 2.7. Distribution of waste water treatment forms in rural areas.

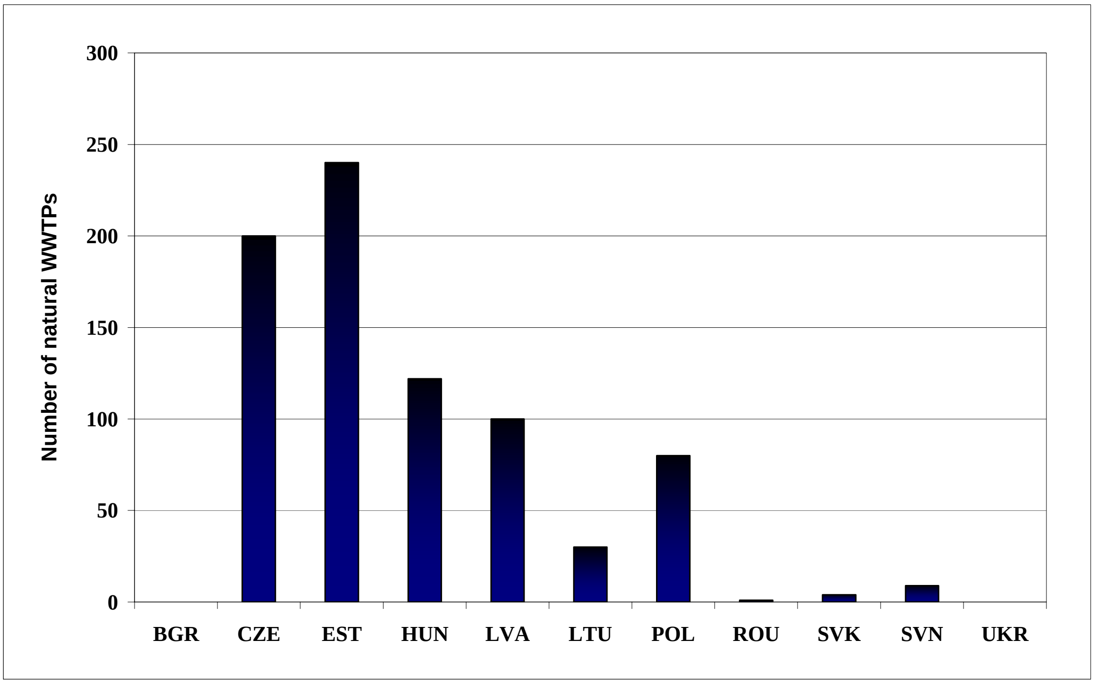
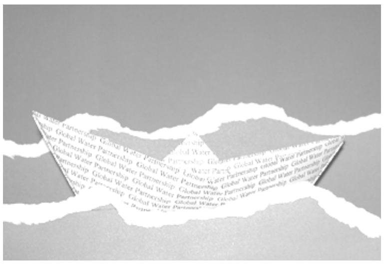


Figure 2.8. Number of natural WWTPs in the CEE countries.

In Estonia and Lithuania there are positive experiences with natural wastewater treatment systems. Most of all, vertical sand-reed filters have proven to be very effective. They can be operated under cold Baltic climate conditions with high treatment effects of organic substances. The condition of the successful application of these systems is effective pre-treatment. On the other hand, in Slovakia only around 10 – mostly wetland – WWTPs were constructed during the last 10 years. Today, there are only three in operation, all of them used as the tertiary stage of the treatment. In Slovakia there is a mostly negative view of the functionality of these treatment processes; opponents argue with large soil demand, inappropriateness of climate and natural conditions, low treatment efficiency and so on.

Generally it can be stated that natural wastewater treatment systems are used only sub-marginally in the CEE countries. The existing systems are either wrongly dimensioned, out-of-date, or with bad operation and maintenance. This has resulted in low expertise and public awareness about the natural wastewater treatment systems and their potential to encompass environmental, social as well as economic targets. On the contrary, the CEE regions are still dominated by national and international "lobbies" for conventional "Concrete and Steel" treatment systems. The promoters of natural wastewater treatment systems are mainly found among ecological engineers, environmental NGOs and "Green Movements" who have difficulties to get the new concepts accepted among a "Business as Usual Establishment" of decision makers and traditional wastewater professionals.

In some European countries like Sweden, Germany and Norway, so called sustainable sanitation systems have been developed and introduced during the last ten years. These new sanitation concepts are designed to meet targets of sustainable development, i.e., systems that are cost effective to meet economic and social targets and advanced environmental protection targets. These systems include source separation of domestic wastewater into different fractions such as grey water, urine and faeces for the reuse of natural resources (nutrients, water and heat). These new sanitation concepts have not yet been introduced in the CEE region.



Chapter 3

What is Sustainable Sanitation and how do I plan for it?

Peter Ridderstolpe & Marika Palmér Rivera

INTRODUCTION

Sanitation is one of the most fundamental functions of society. We have to eat and drink, and therefore we always will produce excreta. To stay healthy, we have to wash ourselves, our clothes and our indoor surroundings. Thus pollution of some water is unavoidable. Appropriate sanitation is imperative for every person's basic needs and the protection of common goods, such as the aquatic environment, drinking water sources and nutrients for food production. It is necessary for planners and decision-makers therefore, to have a comprehensive understanding of role of and methods for sanitation in developing a good and sustainable society.

Originally, human excreta were brought back to nature, where it decomposed and integrated into the cycling processes of elements. When humans started to settle down permanently, excreta started to cause a negative impact on individuals, society as well as nature. Thus, when society developed, regulations and handling systems for excreta management were introduced and developed.

History shows that in all societies around the globe the systems for the management of excreta (and later of wastewater) have been developed from similar basic needs and goals. These can be divided into individual goals and common goals. The individual goals include safe, comfortable and affordable sanitation for the users without nuisance from odour and waste. Where people live as farmers, the safe reuse of human excreta as fertiliser is also among the private goals. The common goals include eliminating waste and health risks from common areas, protecting the environment, and improving food security trough nutrient recycling.

Reuse of the nutrients in human excreta was a main driving force in sanitation in Europe from the middle ages to the end of the 19th century, when waterborne systems were introduced and started to out-compete dry sanitation in cities. In the beginning of the 1900s, focus changed from reuse to disposal[2]. Several reasons explain this shift. One was the structural change in agriculture with access to artificial fertilisers, but also that contamination through excreta and wastewater – mainly of drinking water – was correlated to, for example, cholera epidemics. Thus, health protection was the next important driving force for development of sanitation.

During the second half of the 20th century, the massive and often visible destruction of water bodies outside cities created the third driving force for sanitation – environmental protection. History teaches us that a well functioning and long-term sustainable sanitation system should encompass both the basic private goals and the long-term common goals. To fulfil all these goals is our common challenge for future.

In a 21st century context, sustainable sanitation is a logical consequence of the global commitments expressed in the World Summit on Sustainable Development in Johannesburg in 2002, where sanitation was added to the Millennium Development Goals. A first step towards achievement of both water and sanitation targets was the creation of national Integrated Water Resource Management (IWRM) and Water Efficiency Plans by 2005. A Global Water Partnership survey among 100 countries in 2005 showed that only about 30% had those plans in place and that sanitation is one of the priority issues.

In this chapter, the principles of sustainable sanitation are explained. The chapter has two parts; the first part introduces the concepts of sustainable sanitation, and the second part presents a planning method for choosing the appropriate sanitation solution.

CONCEPTS OF SUSTAINABLE SANITATION

As seen throughout history, the common targets for sanitation and wastewater treatment are protection of public health, recycling of nutrients and protection against environmental degradation. These targets are hereafter called primary functions. For the system to be sustainable, the primary functions have to be balanced against economical, socio-cultural (among them the private goals) and technical considerations. This balance is illustrated in Figure 3.1.

Below, the concepts of sustainable sanitation and sanitation system are further discussed and defined. The primary functions, practical considerations and technical options are also described. To illustrate these concepts, the conventional wastewater treatment system (central compact wastewater treatment plants) is evaluated according to its performance in terms of the primary functions and practical considerations.

What is sustainable sanitation?

The term sustainable sanitation is used in an effort to mainstream sanitation into the concept of sustainable development as agreed upon between the countries at the 1992 UN Conference on Environment and Development in Rio de Janeiro. This means that sanitation solutions should be assessed and be feasible in terms of economic, equity and environmental criteria.

In reality, new infrastructure investments and technologies to serve another 3 billion people, who today lack safe sanitation, should undergo a sustainability assessment before decided upon. This will require stakeholder consultations to find optimal use of available economic and

[2] Drangert & Hallström, 2002.

natural resources as well as to best serve the needs of the people. Sanitation is often part of Integrated Water Resources Management plans at national level. In many cases the Global Water Partnership acts as facilitator to help governments in their efforts to find optimal implementation directions of these plans through stakeholder dialogues[3].

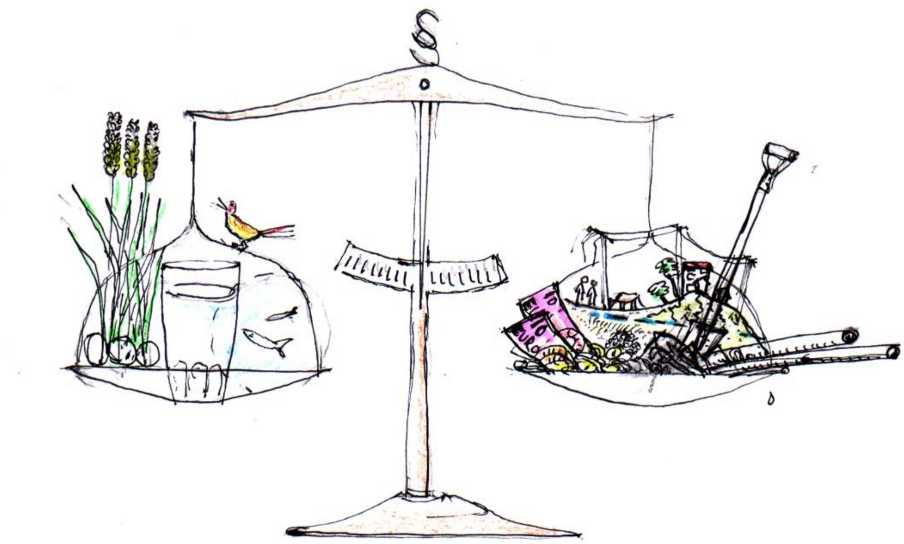


Figure 3.1. The primary functions of sanitation (protection of public health, recycling of nutrients and protection against environmental degradation) have to be balanced against practical considerations. The local situation governs the level of precautions and the technical solution.

Sustainable sanitation can be defined as *sanitation that protects and promotes human health, does not contribute to environmental degradation or depletion of the resource base, is technically and institutionally appropriate, economically viable and socially acceptable*[4]. This definition is used for example, for ecological sanitation in Sweden and Germany[5]. A similar definition is used in the Swedish Research program Urban Water where five aspects of sustainability are considered; health, environment, economy, socio-culture and technical function[6].

Many international organisations stress sustainable sanitation as a fundamental issue to consider when working with human health and development as well as environmental protection. One example is the international collaboration titled the UN Millennium Declaration which many of the world's leaders united behind in the year 2000. The related agenda is named the UN Millennium Development Goals and is supported and implemented by organisations like the World Health Organisation and UNICEF. The aim of the declaration is to reduce poverty and

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[3] GWP, 2003.
[4] Kvarnström & af Petersens, 2004
[5] This definition has been agreed upon by the German International Development Cooperation Agency (GTZ) and the Swedish research program on ecological sanitation EcoSanRes (financed by the Swedish International Development Agency, SIDA) (Kvarnström & af Petersens, 2004).
[6] Malmqvist et al, 2006.

hunger by using sustainable methodologies. Goal number seven, target ten, focuses especially on water and sanitation: *"Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation"* [7].

The task force of the UN project on water and sanitation emphasises long-term considerations and argues that besides environmental and health concerns, additional aspects to take into account should be institutional, financial and technical characteristics when working with the concept of sustainable sanitation[8]. Another example of recognition of sustainable sanitation is the policy for sanitation by the UN Commission on Sustainable Development, which stresses the importance of wastewater treatment that is cost effective and socio-cultural suitable and includes the possibility of reuse of excreta and water[9].

Sustainable development can be defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[10]. Thus, in a sustainable sanitation system, problems are solved on a long-term basis, and not just moved geographically (e.g., untreated wastewater flushed away to a water body out of sight) or in time (e.g., sludge from wastewater treatment landfilled with a slow leakage of nutrients that will cause environmental degradation in the future).

Box 3.1: The relationship between drinking water and sanitation

- Insufficiently treated wastewater can pollute water sources used for drinking water, e.g., with pathogens (disease-transmitting organisms) or nitrate (See section – Protection of Public Health).
- To ensure good public health, drinking water has to be available in sufficient quantity. The sanitation system should therefore not use more water than necessary (See section – Protection of Public Health).
- Agriculture uses a lot of freshwater. The recycling of wastewater for agriculture means that the strain on drinking water sources will be less. Clean and well treated waste water can also be used for recharging groundwater (See section – Recycling).
- The cost of the treatment system depends a lot on the amount of water used, since hydraulic load determines the size of the system, and also affects the amount of energy and chemicals (where applicable) used for operation (See section – Economy).

The sanitation system

When planning and comparing different sanitation systems, the boundaries of the systems must be defined. In research and in long-term strategic planning, the sanitation system might be broad and include agriculture and sometimes the users. Agricultural systems relate closely to sanitation since agriculture produces food that, after consumption, is managed in the sanitation system. In a well connected socio-agricultural system, products from sanitation systems are brought back to agriculture, thus closing the loop for nutrients.

In practical planning and design, it is more useful to define the sanitation system as a technical system only. Thus, the more pragmatic definition of sanitation includes all components, from the sources (e.g., toilet, kitchen sink, and so on.) to the end of the pipe before discharge into the recipient system. In practical planning it is also imperative to consider the interactions between the technical sanitation system and surrounding systems and stakeholders. When designing and assessing the impact of a technical system on users, people living nearby and people yet not

[7] UNDP, 2006.
[8] UN Millennium Project Task Force on Water and Sanitation, 2005.
[9] UN Commission on Sustainable Development, 2005
[10] Our Common Future, 1987

born, economy, institutional capacity, as well as agriculture and the recipients must be considered. A conceptual sketch of the sanitation system is given in Figure 3.2.

The technical system does not necessary mean a facility "of steel and concrete". Natural systems (outdoor systems) can also be used for treatment. Especially in rural areas, irrigation systems, soil and sand filters systems or constructed wetland systems are appropriate for wastewater treatment. The requirements set up for the sanitation system can be achieved by measures all the way from the point of origin to the recipient. Therefore, it is important to be aware of the inlet point as well as the outlet point of the system. In the planning process it is necessary to decide for example, if the system starts inside the house or at the garden edge, how many houses that should be included into the system and if the end of the system must be at a point where all treated water can be measured or if the system can be extended to include for example, part of a field for crop production. In the latter case the performance of system can not be measured by traditional water sampling. Clearly defined system boundaries are necessary for making comparisons of different sanitation solutions, and to assess sustainability of the system. More about planning and comprising different systems is described in the section Planning for Sustainable Sanitation (below).

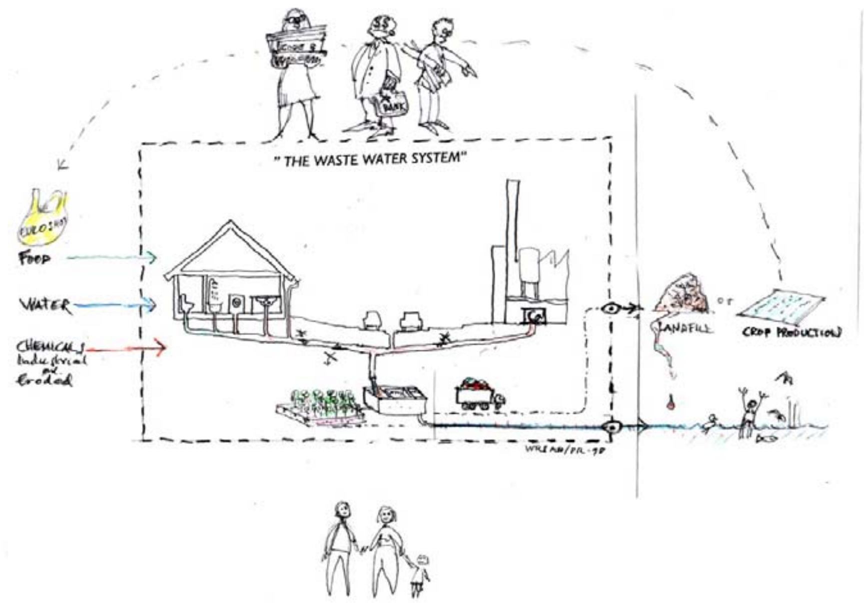

Figure 3.2. A conceptual sketch of the "sanitation system". Within the boundaries of the system (dotted line) are all technical components, from sources to recipients. Measures to protect the environment and human health and to create potential for recycling of water and nutrients can and should be taken within the whole system. Surrounding systems and stakeholders (e.g., water supply system, agriculture system, regulating system, financing system, users of system and nearby and downstream living people) must be considered and their representatives should be involved in the planning process (sketch P. Ridderstolpe 1998).

It is important to be aware of the whole system and to consider that what "goes in goes out". Thus the quality of treated wastewater and rest products (such as faeces, urine or sludge) depends very much on the inputs. For example, if toxic compounds and heavy metals are present in drinking water or in household chemicals, these compounds will be present in the outgoing water or in the rest products. A “system approach” on sanitation thus means that precautionary actions (source control) should always be considered, for example, separation of toilet waste and greywater or reduction of phosphorous in household detergents. To facilitate treatment and recycling, storm water and industrial wastewater should always be kept separate from the household sanitation system.

The primary functions of sanitation systems

As previously discussed, the primary functions of sanitation systems are health protection, recycling and protection against environmental degradation (illustrated in Figure 3.3).

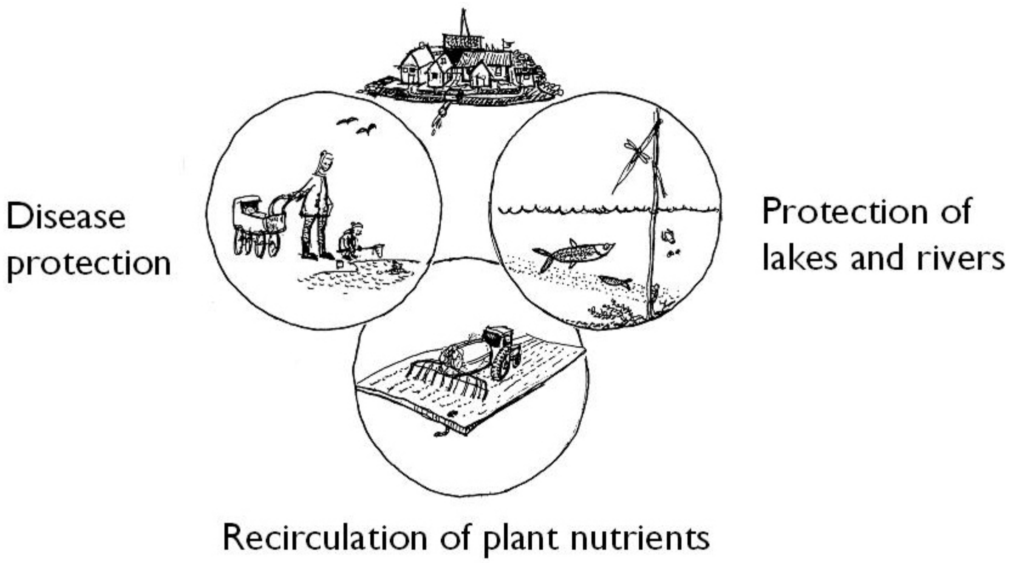

Figure 3.3. The primary functions of sanitation systems: protection of health, protection of the environment and recycling of nutrients[11]. A sustainable sanitation solution should integrate all these functions.

Sanitation systems have to deal with the management of urine, faeces (toilet waste) and greywater (water used for bathing, washing, and so on), either separately or mixed. These different fractions have different characteristics, both in terms of content of pollutants and in terms of volumes. The main characteristics of urine, faeces and greywater; the impacts of different pollutants and possible remediation measures are given in Table 3.1.

[11] From Ridderstolpe, 1999.

Table 3.1. Content in different household wastewater fractions, the environmental impact and means for pollution/impact control[12]. Figures are based on Swedish experiences[13].

Substance	**Content in different fractions**			**Impact**	**Means for control**
	Faeces	**Urine**	**Greywater**		
Water, l/pers,d (flush water incl.)	4-10	20-40	80-200	▪ Scarcity in some places ▪ Heat losses when discharged ▪ Investment in treatment ▪ Logging of ground and buildings	▪ Behaviour ▪ Fee system ▪ Water saving equipment
	Mean all together: New houses: 150 Old houses: 180				
Pathogens	High	Very Low	Low	▪ Infections	▪ Do not mix faeces in water. ▪ Hygienic handling of faeces, e. g by disinfecting by composting ▪ Treatment of water in aerobic biological filters, e.g. trickling filters or vertical sandfilters ▪ Minimise risk for exposure
Organic matter (BOD) kg/pers.year	5,5	2	10	Oxygen depletion may cause ▪ Odour and ▪ Toxic water Fat, oil and growth of bacteria's may cause blockage in pipes, soil pores etc.	▪ Removal by flotation and sedimentation ▪ Aerobic mineralization, e.g. vertical sandfilter ▪ Anaerobic mineralization, e.g. Imhoff tank or constructed wetland
	Feaces + urine = 7,5				
Phosphorous kg/pers.year	0,2	0,4	0,05-0,3*	▪ Eutrophication ▪ Limited resource	▪ Reduce P in detergents ▪ Separate treatment of urine or blackwater ▪ Chemical precipitation ▪ Sorption in soil or reactive filter ▪ Uptake in bacteria, green plants
	Mean all together: 0,8				
Nitrogen kg/pers.year	0,5	4	0,5	▪ Eutrophication (in sea) ▪ Oxygen consuming in water ▪ Energy consuming when produced	▪ Separate handling of urine or blackwater ▪ Treatment in aerobic/ anaerobic biological filters ▪ Uptake in bacteria or green plants
	Mean all together: 5,0				
Heavy metals	present	negligible	present	▪ Toxic for humans treatment system and for the ecosystem	▪ Prevention at source e.g by information and prohibition
Organic toxic compounds	negligible	negligible	present	▪ Toxic for humans, treatment system and for the ecosystem	▪ Prevention at source e.g by information and prohibition ▪ Treatment in aerobic biological filters
Pharmaceutical residues/ hormones	present	present	negligible	▪ Toxic for aquatic organisms	▪ Microbial degradation in the topsoil

*The content of phosphorous in greywater depends on the phosphorous-content in household detergents, in the range of 10-50% of the total content of phosphorous per capita.

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[12] Table prepared by P. Ridderstolpe in co-operation with Coalition Clean Baltic.
[13] Swedish Environmental Protection Agency, NFS 2006:7

As Table 3.1 shows, there are many ways of achieving the primary functions when considering the whole technical syste from the source to the discharge into the recipient. The figures in the table can be used for approximate calculations of nutrient and water loads for initial planning purposes (for design and dimensioning of technical components, more accurate calculations should be made).

Protection of public health
Wastewater is a main pathway for spreading diseases in the world. The World Health Organisation estimates that 13,500 children under the age of 14 die every year in Europe from diarrhoea related to poor water, sanitation and hygiene. Most of these deaths occur in Eastern Europe[14].

The health risk depends mainly on the content of pathogens (disease-transmitting organisms) and is a function of faecal contamination[15]. Urine and greywater usually does not contain high concentrations of pathogens, but may have small amounts as a result of faecal cross-contamination.

Thus, to prevent the spreading of diseases it is necessary to prevent the exposure of faeces to humans. All exposure routes have to be considered, from the user of the system to the handling of the rest of the products and the discharge of treated wastewater. Possible exposure routes are given in Table 3.2.

Table 3.2. Possible exposure of faeces in different parts of the sanitation system and when using end-products in agriculture.

Part of system	**Possible exposure**
Toilet	▪ during and after use ▪ during cleaning
Treatment system	▪ during maintenance ▪ in case of process failure ▪ direct contact with treatment process
Discharge	▪ contact with treated water ▪ using contaminated groundwater as drinking water source ▪ contact with contaminated insects or wild animals
Handling of rest products	▪ emptying of collected rest products
Use of end-products	▪ application on arable land ▪ consumption of e.g. vegetables fertilised with wastewater

Barriers can be used to prevent faecal exposure. The concept of a barrier includes all means to reduce the risk of exposure, for example, restricted access to open treatment processes, wastewater treatment that reduces the content of pathogens and storage of rest products to achieve pathogen die off. If the hygienic quality of treated wastewater is such that it poses a health risk, it can be discharged in a way that prevents exposure until the number of pathogens

[14] 11,000 deaths occur in the EUR-B sub-region (as defined by WHO): Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Serbia, Slovakia, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan and Uzbekistan. From Valent et al., 2004.
[15] World Health Organization, 2006.

has been reduced to safe levels, for example, in a wetland with restricted access. Barriers for the use of end-products on arable land include application techniques and crop restriction[16].

Although infectious diseases are the main health risks associated with sanitation, other compounds present in wastewater can also be hazardous for the health. Nitrates, for example, if leaked into groundwater that is used as drinking water, can cause health problems for small children (sometimes referred to as the Blue Baby Syndrome).

Wastewater may also contain toxic compounds that pose health risks, for example, heavy metals, antibiotics (medicines) phthalates and phenols. Treatment processes generally are not designed to remove these compounds and the best way to reduce the content in wastewater is to reduce them at the source, for example, by reducing the amount of chemicals used in households. To reduce the health risks of these compounds, the concept of barriers from exposure (see above) can be used.

To ensure proper hygiene and thus good health, drinking water has to be available in enough quantity as well as of good quality. In areas where water is scarce, this has to be taken into consideration when designing the sanitation system.

Recycling

In principal, all nutrients we consume are excreted. Beside the macro-nutrients like phosphorous, nitrogen, potassium and sulphur there are also about twenty other micro-nutrients present in toilet waste essential for plant growth. Crop production usually benefits by adding nitrogen but also other elements may limit production, especially in soils cultivated for long time. Aquatic plant growth life is normally regulated by phosphorous and sometimes nitrogen. If these nutrients are discharged into water bodies they cause eutrophication and therefore, the traditional wastewater strategy has been to remove nutrients that fertilise water. However, a sustainable solution means that removed nutrients must be reused. Simply dumping removed nutrients in sludge is an expensive way of moving the eutrophication problem to the future and to other places.

The abundance of chemical fertilisers after the Second World War has made many farmers, at least in the Western part of the world, uninterested in nutrient recycling from toilet waste. The use of artificial fertilisers however, poses several problems. Phosphorous in artificial fertilisers are made from phosphate minerals, which are a limited resource and some phosphate minerals contain high level of heavy metals. Nitrogen can be produced from the un-limited source of nitrogen in the air, but this process is very energy-consuming. Different soils need different composition of macro- and micro nutrients. Balancing this is difficult in artificial fertilising. Thus, to make both wastewater treatment and agriculture long-term sustainable, all the nutrients in toilet waste should be reused in agriculture. Unfortunately the modern agro-society system is a more like linear nutrient flow system from fossil recourses to deposits in recipients (see Figure 3.4).

In areas with water scarcity, the recycling of water may also be an important function of the sanitation system. Agriculture consumes very large amounts of freshwater, and the recycling of wastewater through irrigation reduces the pressure on drinking water sources. Water saving is further discussed in the section Economy and Resource Management (below).

[16] World Health Organization, 2006.

Solving one problem should not create new problems, and therefore, nutrient recycling should be performed in an appropriate way. There are some risks associated with recycling of toilet waste and wastewater, including faecal contamination (transmission of infectious diseases), increased salinity of soils (for wastewater irrigation, in semi-arid or arid climates) and increased content of heavy metals or other toxic compounds in soils and on crops.

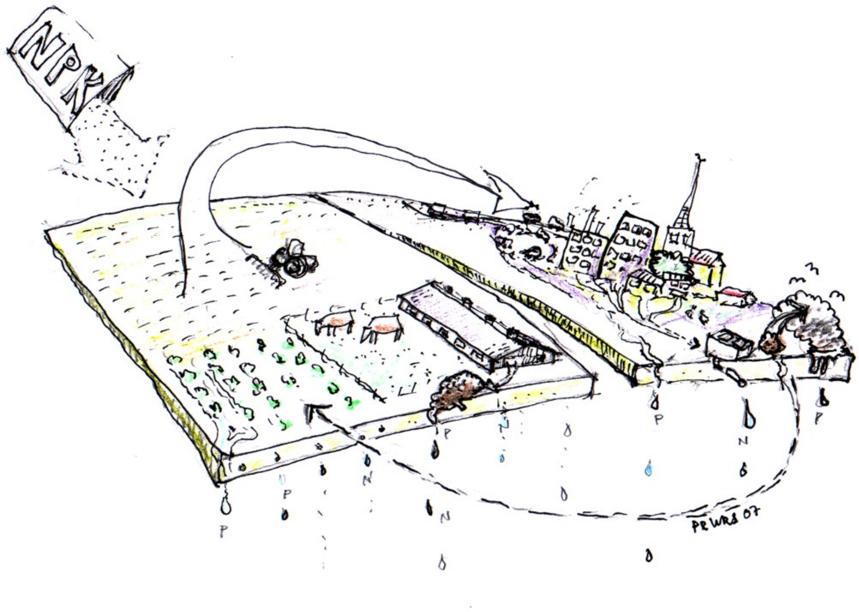

Figure 3.4. Chemical fertiliser has created modern agriculture independent from recycling nutrient from the toilet waste. Lack of incitement for "closing the loop" make agriculture into a leaking system of nutrients to ground water and surface water. Only a small amount of all added nutrients in artificial fertiliser is transformed into the food transported to society. After consumption, the nutrients are excreted and released to wastewater. In our modern society (also when conventional wastewater system are used) very little of these nutrients are brought back to agriculture. The result is a polluting and a not sustainable agro-society system (Sketch P. Ridderstolpe 2007).

However, the risks can be very well managed. Hygienically safe and efficient methods for the application of toilet waste to arable land have been developed. The World Health Organization has published guidelines for the safe use of wastewater, excreta and greywater (World Health Organization, 2006). According to the World Health Organization, "the direct use of excreta and greywater on arable land tends to minimize the environmental impact in both the local and global context"[17].

Resource management is also an economic and practical issue and is further discussed in the section Economy and Resource Management (below).

[17] World Health Organization, 2006.

Protection against environmental degradation
Eutrophication is a serious environmental problem caused by insufficiently treated wastewater and leads to excessive plant growth and decay, favours certain weedy species over others and thus causes severe reductions in water quality. The extensive algal blooms in the Baltic Sea during summertime in recent years are an effect of eutrophication.

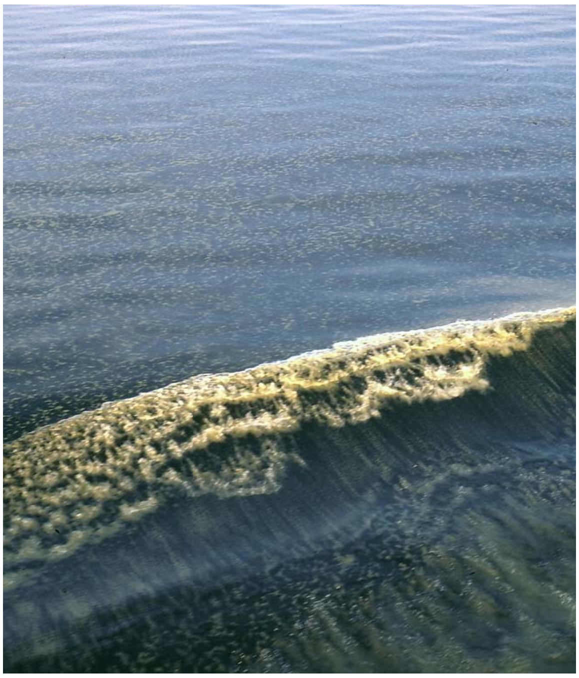

Figure 3.5. Environmental effects from insufficient sanitation; increasing algae blooms in the Baltic Sea. *Photo P. Ridderstolpe 1998*

The high content of organic matter in untreated wastewater can lead to oxygen depletion if released into water bodies. Dissolved oxygen in water bodies then sink below levels that are healthy for life, which can lead to death of fish and other aquatic fauna. The plant nutrients in wastewater damage the water eco-system even worse. Growth of algae and other organisms is stimulated and organic load to the water ecosystem increase. In oxygen-depleted waters, phosphorous can be released from anaerobic sediments and lead to further eutrophication. Such situation with accelerating "evil spiral" of eutrophication is hard to break. Eutrophication effects are more rapidly visible in small water recipients but large and deep recipients are sensitive and recover very slowly from damages. The Baltic Sea and the Black Sea are both sensitive waters that from decades of pollution now suffer from the "evil spiral" of eutrophication (Figure 3.5).

Toxic compounds present in wastewater, such as heavy metals, organic chemicals and medicines, pose environmental problems as well as health risks, since they are toxic to aquatic and terrestrial organisms. These compounds are difficult to remove in wastewater treatment processes and are best reduced at the source (see above, protection of public health,).

Soil and groundwater are sometimes used as recipients. Processes in the soil, such as microbial activity, means that the wastewater content of organic matter and nutrients is further reduced before the wastewater reaches the groundwater. Soil is therefore, less sensitive as recipient than water. However, non-biodegradable toxic compounds can accumulate in soils through adsorption on soil particles. Using groundwater as a recipient can be problematic, since the effect of soil processes on wastewater is highly dependant on local soil and groundwater conditions and can be hard to predict without detailed surveys. Changes in groundwater quality are difficult to see and may not be noticed until the contamination has gone too far for remediation.

When setting targets for sanitation and wastewater management, it is important to distinguish between local and regional environmental protection. Discharges that only have a marginal effect on regional water bodies may have a large impact on a small local stream or lake.

Saving energy and recourses used for wastewater treatment save money and are often economically reasonable. For example, a treatment work built on supply of large amounts of electricity or chemicals create high running costs, which can be hard to pay in the long run. However, the environmental effects of the discharge of wastewater represent a far more energy- and resource consumption due to losses of heat, fresh water and plant nutrients[18]. This cost is seldom counted in private economy. Instead these costs are overload to be paid by future generations.

Practical considerations for sanitation systems

As previously discussed, the primary functions have to be weighed against practical considerations, including the costs, socio-cultural aspects (users, institutional capacity, legislation, etc.) and technical functions to achieve a sustainable sanitation system. The practical considerations are discussed and exemplified below.

Financing

Costs for sanitation should be reasonable, and what is reasonable depends on the local context, i.e. what users are able and willing to pay for the system and how the system will be financed (loans, grants, etc.). The institutional capacity to collect payment from users is important for a public system financed by the users. For comparisons between different solutions, the annual costs should be used. Annual costs include capital costs (investment divided by the depreciation time in years plus interests) and annual costs for operation and maintenance.

Costs depend on many factors, including targets and natural conditions (topography, soil, etc.) on-site. The water load often determines the size of treatment facilities, thus savings in water consumption (e.g., by installation of water saving equipment) can lead to lower costs. Operational costs include costs for electricity (or other types of energy), personnel, chemicals, handling of sludge or other rest-products and costs for monitoring. Water savings generally lead to savings on electricity, chemicals and sludge treatment. A natural treatment system (with minimum input of electricity and chemicals) where operation and maintenance is performed by the users has very low operational costs.

A socio-economic factor to consider is the local development connected with the sanitation system, that is, the possibility to use local competence for construction, operation and maintenance, thus creating local jobs.

Socio-culture

For users, the driving-forces for improved sanitation systems are different from the public driving-forces. Users want a safe, convenient and affordable solution that does not require more work than necessary. What is considered safe and comfortable depends on the cultural context. The system should be adapted to needs of different age, gender and income groups. If the individual goals are already met in an existing system, the willingness to pay for a new improved sanitation system (to fulfil common goals) may be considerably lower than the capacity to pay. The willingness to pay may be increased by fair consumption fees, an efficient organisation and high reliability of services[19]. Awareness raising and education of the user may be needed to use the system correctly.

[18] Kärrman & Jönsson, 2001.

[19] Malmqvist et al, 2006.

A clear division of responsibility for management, operation and maintenance is important for sustainability[20]. Several different forms of ownership and responsibility are possible; the system can be owned and managed privately by each household (feasible for decentralised on-site systems), by the municipality (public ownership) or by a joint association of households. A combination is also possible, for example, the collecting system is privately owned but the treatment plant is owned and maintained by the municipality.

A sustainable sanitation system requires public institutions that are able to handle the different tasks needed, such as operation and maintenance, recollection of fractions for reuse, education, monitoring and recollection of payment from users. The institutional requirements are different for different types of sanitation systems, and have to be specified for each specific situation. The sanitation system has to comply with requirements stated in legislation. The legislation regarding sanitation systems on a European level is further discussed in Chapter 5.

Technical function

System robustness is perhaps the most important technical aspect for long-term sustainability and includes the risk of failure and the effect of failure. The system should also be robust concerning the use of the system, it should fulfil treatment objectives all year round and for varying loads. This is especially important for small-scale systems where the load varies greatly.

Depending on the local context, robustness against extreme conditions (floods, etc.) may also be an important aspect of the technical function. Other technical aspects to consider include flexibility (how easily the system can be adapted to changes in circumstances), durability and compatibility with existing systems.

Monitoring is important to make sure that sanitation systems are working properly. The three main types of monitoring include validation, used when a new system is developed to see that it can meet specified targets; operational monitoring, performed routinely to indicate that processes are working as expected; and verification, performed on the end-product (e.g., treated wastewater, excreta, urine, plants fertilised with excreta) to see that it meets treatment targets[21]:

Verification is often costly if it is done properly since a large number of samples have to be taken to get a correct result. Therefore, operational monitoring is usually more viable for small-scale systems. Validation means that the type of treatment process/technology used has been previously evaluated, which should always be the case for small-scale applications not intended for research purposes.

Screening of technical options

When choosing a sanitation system, the focus should be on the function of the system, that is, performance regarding primary functions as well as practical considerations. Technology is a means of achieving these goals and not a goal in itself. It is important that user and institutional capacity (software) is compatible with the technical system (hardware).

The technical solution for the sanitation system is chosen from desired performance and from local conditions. Thus, technology used in different situations will differ. Both conventional and

[20] Söderberg & Johansson, 2006.
[21] World Health Organization, 2006

new "ecological" technologies may be relevant and should be considered and evaluated in a planning situation.

An overview of different technologies for sanitation/wastewater management is given in Table 3.3. Detailed technical descriptions of sanitation/wastewater systems are beyond the scope of this paper.

Table 3.3. Technical options for different functions of wastewater treatment[22]

	"Conventional" treatment technology (intensive / indoor)	**Natural treatment technology (extensive / outdoor)**
Pretreatment – removal of suspended solids	Screens Grids Sieves Pre-sedimentation tanks	Sedimentation ponds Septic tanks Mulch filter(a living soil)
Removal of BOD (secondary treatment)	Trickling filters Biorotors Activated sludge	Stabilization ponds (Dry) wetlands Vertical soil filters (infiltration, sandfilters) Irrigation
Removal of phosphorous (Tertiary treatment)	Chemical precipitation in wastewater treatment plants. Bio-P Osmotic filters	Precipitation ponds Infiltration Reactive filters (horisontal filters) Irrigation
Removal of nitrogen (Advanced treatment)	Nitrification + denitrification in wastewater treatment plant, Struvite precipitation, Ammoniac stripping	Nitrification + denitrification in dry+ wet wetlands, or sand filter + wet wetland Irrigation
Sludge management (dewatering, stabilisation, hygenisation)	"Thickeners" Sieves Centrifuges Fermentation (composting, lime-stabilisation)	Drainage beds Biological drainage beds (Reed beds) Long time storage Composting Lime-stabilisation Nitrogen- hygienisation

As Table 3.3 shows, there are many different technologies for sanitation and wastewater treatment. Although treatment in wastewater treatment plants seems very different from natural treatment methods, they are all based on the same general principles. To get a well-functioning sanitation system, the technical system has to be adapted to local conditions and ambition. Natural system is often appropriate for small-scale and medium-scale sanitation systems. They are robust and reliable, and efficient if designed properly. They also have potential for saving energy and costs and are often easy to operate and maintain.

[22] Table prepared by P. Ridderstolpe in co-operation with Coalition Clean Baltic.

Box 3.2. An assessment of conventional wastewater treatment systems

The conventional wastewater management system, where household wastewater is collected in sewers and transported to a centralised advanced treatment plant, is often considered the norm with which all other sanitation solutions are compared. A review of the conventional system on the basis of the primary functions and practical considerations previously presented, however, shows that this solution has several drawbacks as well as advantages (summarised below).

Primary functions

- *Health protection*
  - Transfer of hygiene risks into recipient lakes and streams.
  - High risk of disease transmission during process failure.
- *Recycling of nutrients*
  - Not part of the concept. Nutrient-rich sludge is often land filled. Nutrients are mixed with toxic compounds in the sludge. Methods for extracting nutrients from sludge are under development, but expensive and unreliable.
- *Environmental protection*

  Efficient in terms of lake and sea protection from eutrophication.

Practical considerations

- *Economy*
  - Costly investments, thus demanding a well developed institutional capacity for planning and financing
  - Costs to be paid by economically weak (and partly poor) users
- *Socio-culture*
  - Efficient in terms of disposal of voluminous amounts of waste and protecting users from immediate nuisance and infections
  - Flush sanitation widely accepted by users. High status in many parts of the world.
  - Sophisticated technique demanding special capacity in planning, implementation, operation and maintenance
- *Technical function*
  - Poor and uneven supply of water makes toilet system unreliable.
  - High risk for stopping and process failure, require constant monitoring and maintenance

The “classical” wastewater treatment system with compact plants is efficient for what it has been designed for, which is to reduce nuisance and infections in the immediate surroundings, and to protect water recipients from eutrophication. However, other targets, such as recycling and technical robustness, are not fulfilled.

For the system to perform well, the economic as well as the institutional capacity has to be well developed. This is rarely the case, and therefore conventional wastewater treatment systems do not achieve sufficient treatment in most places of the world. Only about 30% of the 1.1 billion people served by sewage systems have treatment equipped by secondary treatment (removal of biodegradable organic matter) or better (removal of phosphorous or nitrogen)[1]. Of 540 major European Union cities, almost half have incomplete primary or secondary treatment or less (EU, 2001).

Sweden has well-developed conventional wastewater treatment systems, where about 95% of the population are connected to central wastewater treatment plants. However, this has been financed mainly by state subsidies, and not by the users. Thus, economic capacity in society and willingness to pay among the users must be high to bear the investment costs in a conventional water-borne wastewater with high treatment performance (i.e., according EU legislation).

PLANNING FOR SUSTAINABLE SANITATION

When making decisions on systems for sanitation and wastewater management, the concepts described in the previous section have to be put into practice. A structured planning method can make this process easier. Several different methods have been developed for this purpose, with different levels of complexity and accuracy, for example:

- *The Logical Framework Approach (LFA)*, a planning tool where problems and options are identified in a general context, but does not give specific guidance in choosing system for sanitation. The approach is used by many international development organisation[23].
- *The Water and Sanitation Programme by UNDP and the World Bank* propose a demand-driven planning procedure for sanitation, where the main target group is founders and appliers of urban sanitation programmes, for example, governments and donor agencies[24].
- *Environmental Impact Assessment (EIA)*, a systematic methodology for examining the impact on the environment of a proposed project, designed to assess environmental consequences of a planned project and not to give guidance in choosing between different options.
- *The Urban Water Programme*, a Swedish research programme for sustainable water and wastewater systems has designed a conceptual framework for guiding planning, which is useful in large projects and in situation where strategic choices on large investments must be made.
- *The Strategic Choice Approach (SCA)*, a planning methodology with the aim to enable decision-making and communication among stakeholders used for example in urban planning including sanitation systems and sustainable development in the developing world[25].
- *Open Wastewater Planning* is a planning tool helping stakeholders (users, owners and regulators) to have a creative communication on aims and options, which has been developed in Sweden specifically for planning of sanitation. Below, the method is described further.

The method Open Wastewater Planning is used here. It is a simple and flexible method that can be used for planning both on the macro level (comprehensive planning of sanitation, for example, on a national level) and on the micro level (a specific sanitation project). Decision in planning, such as choice principle solution, design and location etc. is based on site conditions and an assessment of the environmental impacts. Thus, Open Wastewater Planning follows the principles included in EU law (see Chapter 5) and the sustainable criteria described in this chapter.

Open Wastewater Planning focuses on the desired performance of the sanitation/wastewater system, rather than on a specific technology. The framework for the planning method is the principle of the “Best Available Technology” (BAT) and the “Polluter-Pays Principle (PPP)”[26]. The BAT principle states that the best available technology that is economically and practically feasible should be used. PPP means that those who cause pollution should pay for the necessary remediation measures.

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[23] SIDA, 2004.
[24] UNDP-World Bank Water and Sanitation Program, 1997
[25] Friend & Hickling, 1997
[26] The planning method Open Wastewater Planning has been developed by Peter Ridderstolpe and is described in e.g. Ridderstolpe (2000) and Ridderstolpe (2004).

The Open Wastewater Planning method changes preconceived thinking, creates a deeper understanding of the objectives for treatment and forces decision makers/other stakeholders to consider the whole system. The method also creates understanding of the software part of the system (user aspects, institutional aspects, economical aspects, etc.). It promotes locally adapted systems and development of new technologies. A lot of effort is placed on the initial planning stage. This extra time and money invested in early planning generally leads to better adapted, and thus more cost-effective, sanitation solutions. An independent expert with good knowledge on legislation and sanitation solutions should facilitate the planning process. The participatory approach promotes public participation and makes the planning process more democratic.

The planning process: Open Wastewater Planning

The Open Wastewater planning process can be divided into five steps[27] described below. To illustrate the planning method, the specific planning case of upgrading a small worn-out wastewater treatment plant in Vadsbro, Sweden, is used to exemplify each step[28].

Step 1: Identification of the problem and initial ideas for solutions.

First of all an assessment of the current situation has to be made and the problem identified. An initial discussion takes place about possible targets for the future new or reconstructed sanitation system as well as strategies and different technical principles. Practical, legal and economical prerequisites important for implementation are assessed.

All relevant stakeholders should be involved in the planning process. Therefore, stakeholders and their roles have to be identified. Stakeholders may include:

- Residents: users and sometimes owner of the planned sanitation system.
- Planners, regulators and political decision makers (e.g., municipal planning and environmental authorities).
- Land owners (owners of the land where components of the sanitation system will be located).
- Contractors (they may be involved in the construction and/or operation and maintenance of the system).
- Farmers (users of treated waste products and, possibly, reclaimed wastewater).
- Community-based organisations.
- Other stakeholders, e.g., neighbours with freshwater wells, people living downstream.
- Engineers, both public and private.
- Funding agencies.

In practice, especially in minor projects, it is not possible to assemble all stakeholders in meetings. Instead the sanitation expert (the "facilitator" mentioned above) has to gather the opinions from different stakeholders.

[27] Based on Kvarnström and af Petersens, 2004

[28] Ridderstolpe, 1999

Box 3.3: Problem and stakeholder identification in Vadsbro

Vadsbro is a small community in the countryside. A sewer system connected the forty households to a run-down treatment plant. The sewage runs by gravity to a pump station from which it is pumped to the treatment plant. The plant is situated near a small excavated river/ditch that drains the village, forest and farms upstream. The treatment plant is surrounded by flat farmland and the owner of the land west of the treatment plant was willing to allow it to be used as part of the wastewater treatment.

The poorly functioning treatment plant needed upgrading to meet the wastewater discharge standards set by the local municipality. The project was initiated after student reports from a nearby school had shown that alternatives to building a new treatment plant in Vadsbro existed.

Stakeholders included the residents, the municipality, the landowner/farmer and the school. They were involved early in the process, and although the project was mainly a political process within the municipality, villagers showed great interest in the planning process. A village meeting was held, which a majority of the villagers attended. Several meetings at the municipality were held as part of the process, and the farmer/landowner was an interested and important participant.

Step 2: Identification of planning prerequisites and definition of system boundaries

The planning is based on the targets (functions to be achieved) of sanitation and from practical, legal and economical conditions on site. The boundary of the system is the basis for the Terms of Requirement (step 3) and for the design of the system. The planning conditions that need to be identified include:

- Number of people connected, at present and in the foreseeable future.
- Loads of water and pollution.
- Natural conditions, including groundwater conditions, location of nearby lakes and streams, precipitation, topography, soil conditions, etc.
- Existent system – what can be used?
- Possibilities for reuse of nutrients.
- Waste flows within the area.
- Users: willingness and capacity to pay, socio-economic patterns, cultural context.
- Legal framework.
- Financing (users capacity for paying).

The boundaries of the technical sanitation system need to be identified, as previously discussed. The system boundary definition is important for cost calculations, the definition of responsibilities, and for selecting a sampling point for, if applicable, outgoing wastewater.

Box 3.4: Planning conditions and system boundaries in Vadsbro

The treatment plant is located along a small stream, which is also the receiving water. The stream flows in to Lake Vadsbro. A beautiful place, which is used for recreation, is located close to the outlet in the lake. Lake Vadsbro is sensitive to eutrophication, and hygienic problems may occur at the bathing beach in the lake.

At the time of planning, 125 persons were connected to the treatment plant. No great increase is expected in the future, and the planning was based on 140 persons, which would mean (with the same leakage into the sewers) a mean wastewater flow of 45 m^3/day. The amounts of nutrients were calculated from Swedish standard figures.

The system boundaries were set to include the existing system with sewage pipes, pump stations and buildings, and also extended to incorporate an outdoor treatment.

Step 3: Articulating Terms of Requirement (ToR) and possible technical principle solutions
The Terms of Requirement express minimum levels of the primary functions that can be achieved from what is practically and economically reasonable. Thus, the articulation of the Terms of Requirement is a balance of targets against practical and economical considerations. It is the most important step in the planning process, since all decisions on system design will be based on the Terms of Requirement. During the process different technical options should be investigated to see if the Terms of Requirement are realistic. To confirm the targets and the practical/economical consequences in the Terms of Requirement, stakeholders (as identified in Step 1) should participate in this discussion. The Terms of Requirement are set up with primary targets on one side and practical considerations on the other, so that they are balanced against one another.

Table 3.4. Terms of Requirement for Vadsbro. The Terms of Requirement for the sanitation system in Vadsbro were based on the Swedish environmental legislation, the sensitivity of the recipient, and the wish for a locally adapted system expressed by the villagers and the municipality.

Primary functions	**Practical considerations**
Protection of public health ▪ Avoidance of sanitary nuisances, e.g. bad odour. ▪ The effluent should either be of bathing water quality or excluded from direct exposure to humans until it has achieved bathing water quality. *Recycling* ▪ Phosphorous: >75% recycled. ▪ Other resources valuable for agriculture. *Protection against environmental degradation* ▪ Phosphorous: >90% reduction. At most 0.1 kg/pe as annual discharge and <0.1 mg/l. ▪ Nitrogen: >50% reduction. At most 2.5 kg/pe as annual discharge. Discharged in the form of nitrate. ▪ BOD: >95% reduction.	*Economy* ▪ Investment should not exceed USD 4000 per household. ▪ Operation and maintenance should not exceed USD 250 per year per household. *Socio-culture* ▪ New systems may require new responsibility arrangements between the municipality and farmers. ▪ Nutrient recycling should be adapted to the possibilities in the area. ▪ The system should be adapted to present and future land use in the area. *Technical function* ▪ A proven, robust system that gives few surprises. ▪ Use of existing infrastructure when feasible. ▪ Discharge monitoring may be more challenging for new systems and could require new methods.

Step 4: Analysis of possible solutions
In this step, different principle solutions (they are probably already discussed in Step 3) are investigated and described. When finding alternative solutions all possible measures for achieving the targets, from the source to the recipients, should be considered. At least three options that comply with the Terms of Requirement should be developed and described on a pre-design level. This means that all new system components should be described technically in terms of dimensioning, designing and location/installation. Cost for building and maintaining should be estimated.

All options should be described in a way that makes them understandable to non-experts. Sometimes it is necessary to go back to Step 3 to redefine the Terms of Requirement, if no feasible solutions that comply with both the primary targets and the practical considerations can be found.
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Box 3.5: Analysis of possible solutions in Vadsbro

Several different solutions for Vadsbro were proposed and discussed. Among them were four different wastewater systems with decentralized solutions that were not accepted by the stakeholders. The reason for that was that the centralized system already existed and the sewers had recently been renovated.

The feasible sanitation solutions identified for Vadsbro were:
1. Primary treatment, winter storage and forest irrigation during summer.
2. Stabilization ponds with chemical (lime) precipitation.
3. Primary treatment, trickling filter and biofilter ditch.
4. Primary treatment, trickling filter and crop/wetland rotation.
5. Primary treatment, sand filter and biofilter ditch/wetland.
6. Package treatment plant (sequencing batch reactor, SBR), including nitrification followed by a biofilter ditch or wetland.

The solutions were presented with simple sketches to show how each alternative worked technically and also its compliance with the Terms of Requirement. A rough estimate of investment and operation and maintenance costs was also given for each of the six solutions.

Step 5: Choice of the most appropriate solution
The final choice is made in consensus with future users and other stakeholders. To facilitate this choice, the alternatives presented in Step 4 are evaluated according to Terms of Requirement using, for example, a matrix scoring exercise.

Box 3.6: Final choice of solution in Vadsbro

To compare the six alternatives proposed for Vadsbro, a matrix scoring exercise was performed.

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Health protection	-	++	++	-	++	-
Recycling	++?	++	++	+++	++	++
Environ-mental protection	+++	++	++	++	++	+
Economy	+++	+++	++	++	-	--
Socio-culture	-	+(+)	++	++?	+	++
Technical function	-	++	++	-	+++	+++
Conclusion	Very efficient and cheap, but hygienic hazards.	Efficient, robust, service-demanding	Efficient, cheap, flexible, robust.	Not enough experience, but very interesting.	Efficient, but quite expensive.	Simple planning, but not cost-efficient.

Alternative 6 (the package treatment plant) was initially the favoured alternative, but after having discussed the consequences of each alternative in relation to the Terms of Requirement with the sanitation expert, the stakeholders finally settled for alternative 3 (Primary treatment, biological treatment in trickling filter and biofilter ditch). Costs and risks associated with the alternatives were decisive for the choice of solution, and alternative 3 was seen as both less expensive and more efficient for pollutant reduction and nutrient recycling than the other alternatives. Alternative 3 also allowed for pre-precipitation during winter operation.

Open Wastewater Planning in typical situations found in the CEE countries

The Vadsbro example above is a situation typical for many small villages in the eastern Baltic Sea region and in other former Soviet Union countries. In planning for retrofitting systems like this or new ones, the Open Wastewater (OWP) planning method is useful. Below, three conceptual cases of typical sanitation situations in the CEE region are described from the concept of Open Wastewater Planning.

Example 1: Upgrading an obsolete treatment plant in a small village

This case is based on a planning situation for a small village on the island Saarima in Estonia. Resident people have low incomes and unemployment is high. Wastewater treatment relies on an old Soviet built wastewater system that needs to be upgraded. In the existing wastewater system, mixed wastewater is collected and treated in a treatment plant with a bioreactor and bio-ponds. The system is over-dimensioned and very energy-consuming. Treatment performance is poor and the outlet water contaminates a small nearby stream. Groundwater is scarce and sensitive to contamination.

The planning process starts with a discussion of the situation with people in charge to identify problems and possible solutions. As a framework for discussions, the existing system is sketched and described in terms of (lack of) environmental benefits, hygiene risks and costs. In the first meeting, the local mayor, the municipal environmental authorities, and persons responsible for operation and maintenance of the existing wastewater treatment plant participate. After identifying the basic planning conditions, Terms of Requirement are expressed and possible options for upgrading outlined. For calculating flow of waters, BOD load, and nutrients, standard figures (see Table 3.1) and number of connected people are used. The system is defined as including all the houses connected to the existent wastewater treatment system and to the recipient. The boundary between treatment and recipient is defined for each alternative.

Investigation shows that the existing collection-, discharge- and treatment-system (bioreactor and bioponds) is in quite good condition and can be reconstructed. Thus it is an advantage if the new sanitation system can reuse some of the infrastructure from the existing system. The Terms of Requirement concludes that the future system must protect the stream (improving water quality for crayfish and perch is set up as a target) and secure drinking wells from contamination. Most important for people is that system should save electricity, and thus costs (electricity bills have doubled in just a few years), and preferably create benefits in terms of new jobs.

Based on the developed Terms of Requirement and the planning conditions (dimensioning criteria), three alternatives for wastewater treatment are selected for further study. The options are:
a) Forest irrigation (described in Chapter 4, Sweden and Hungary).
b) Precipitation in ponds (described in Chapter 4, Sweden).
c) Compact treatment plant.

The assessment of the different options shows that the compact treatment plant (alternative c) is the least attractive alternative since it is expensive and less efficient in terms of fulfilling the primary targets (especially health protection) than the other alternatives. The two other alternatives both have their advantages. After a discussion among the stakeholders, precipitation in ponds (alternative b) is chosen, since it is a robust system all year round and can be built by local competence and from existing infrastructure.

Example 2: Building a new settlement in a peri-urban area
In this situation, based on a case in Lithuania, a new settlement (about 30 houses) is planned for "middle or high income earners" in a nice area outside the city far from the existing centralised sewer system. The land is owned by a local contractor that will build the houses and sell them to future residents. One of the selling points of the housing area is the nearby bathing beach located in a small lake.

The exact number of houses to be built in the area is not known at this stage and the land developer want to exploit the area stepwise. Exploitation of the area plans to take between 3–10 years. To avoid investment in infrastructure without income, individual solutions for each house are desired. The land developer realises the value to install water saving equipment and modern sanitation solutions since all can be planned from beginning.

Initial contact with the municipality makes clear that onsite solution may be problematic. The "environmental bureau" at the municipality had bad experiences from older onsite systems (such as latrines and cesspools). Therefore, they recommend to connect the centralised system or to build a sealed tank from which blackwater should be transported to the municipal treatment plant.

After some discussions with “an expert in OWP”, a local farmer and an NGO organisation the land developer decided to investigate solutions based on “ecological principles”. Terms of Requirement are articulated where health protection and environmental protection are stressed. Since the commercial idea for land developer is to offer people a nice and beautiful environment for living, he is aware of the importance of making as little negative impact on environment as possible (e.g., the nearby lake is planned to be used as a recreation site for the future residents). Nutrient (and water) recycling is also among the targets, since the farmer is interested in applying the best products on his fields. The land developer wants a comfortable system that is easy to operate and maintain, and one that will not make the houses less attractive for selling to high income families.

Based on the planning conditions and the Terms of Requirement, the following alternatives are investigated further:
a) Conducting to an existing centralised wastewater treatment plant in the city.
b) Black water system (blackwater and greywater handled separately) (a simplified version of the systems described in chapter 4, Germany).
c) Urine diverting system by double flush toilets.
d) Storage and forest irrigation (described in chapter 4, Hungary and Sweden).

Alternative (a) is investigated for comparison as the municipal authorities originally favoured that system. After comparing and evaluating the four alternatives according to the Terms of Requirement, alternative (b) is chosen since it is seen as the most hygienic solution and the rest product is more adapted to the needs of the farmer. The land developer is sceptical to the forest irrigation option (d) since he believe that a wastewater irrigated forest close to the house area should not be accepted by his target group of buyers. Alternative (c) was seen quite interesting but concern where raised about mixing faeces into the water since recipient of treated wastewater is the groundwater.

Example 3: Improved sanitation for poor people in a rural area
This case is from a rural area in Bulgaria where families have low income and the unemployment is high. Household farming is common. The area has carts bedrock, shallow soils and sensible groundwater. The existent sanitation systems consist of simple pit latrines that do not function properly, since they contaminate the groundwater and create nuisances for the users such as flies and odours. Drinking water is supplied from private wells.

The planning process starts with discussions where the users get the opportunity to declare their needs and wishes regarding a new sanitation system. The local municipal authorities see the existing systems unacceptable since especially children suffer from pathogen contaminated waters from shallow wells. Plans exist to develop the village for trusting but existing sanitation in village hinder such developments. Therefore when articulating Terms of Requirement, one stress the protection of groundwater and the drinking wells. Recycling of nutrients is seen interesting since the households cannot afford chemical fertiliser. It is obvious that the system must be very robust, easy to operate and maintain by the users themselves. Also cost for investments must be low since subsidies or grants are difficult to obtain for rural development. Since electricity supply is sometimes erratic, the system should function without electricity. It should be possible to adapt the system to varying household sizes. For the users, the most important target is to achieve a sanitation system that is clean, comfortable and safe.

Centralised solutions are not within the economic capacity for the municipality and the users. Therefore, only decentralised on-site solutions are considered. Based on the Terms of

Requirement and the planning conditions, the solution alternatives selected for further study are:
a) Existing pit latrines improved by ventilation and continued grey water handling by throwing buckets in the yard.
b) Dry urine diversion and on-site grey water managing in a constructed soil filter
c) On-site water borne system and treatment in decentralised soil filters.

At the beginning of the discussion, the waterborne system (alternative c) was the alternative favoured by the users, since flush sanitation has a high status. However, after comparing the performance of the waterborne system with the Terms of Requirement, the users realize that a dry sanitation system better meets their needs and is more cost-efficient. Alternative (a) is simple but experience has shown mixing of urine and faeces create nuisances, such as flies, and make the recycling process more difficult. Also, especially women wanted to get rid of the "bucket system". Alternative (b) seems to fullfils the Terms of Requirement best and it is decided to start up a project to develop this system in the village. A test facility shows that separation of urine and faeces make the rest products relatively easy to handle. Urine is found to be a good fertiliser for berries, maize, spinach and other local crops. Based on experiences from the pilot project dry sanitation is developed in the village. As a "spin off effect" a local market is developed for toilet manufactures and entrepreneurs.

READ MORE

Below is a list of references to more information on sustainable sanitation. All the references can be downloaded from Internet (at the time of writing).

General:

- The Urban Water Research Programme: www.urbanwater.org.
- The EcoSanRes Programme: www.ecosanres.org
- Winblad, U, Simpson-Héberg, M. (2004) *Ecological sanitation*. Revised and enlarged edition. Stockholm Environment Institute. http://www.ecosanres.org/pdf_files/Ecological_Sanitation_2004.pdf
- Ridderstolpe, P. (2004) *Introduction to Greywater Management*. Report 2004–4, EcoSanRes Publications Series. Stockholm: Stockholm Environment Institute. http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR4web.pdf

Planning:

- Kvarnström, E., af Petersens, E. (2004) *Open Planning of Sanitation Systems*. Report 2004–3, EcoSanRes Publications Series. Stockholm: Stockholm Environment Institute. http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR3web.pdf
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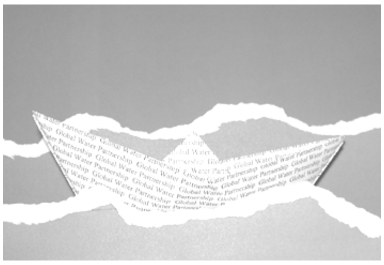
Recycling:

- Jönsson, H., Richert Stintzing, A., Vinnerås, B., Salomon, E. (2004) *Guidelines on the Use of Urine and Faeces in Crop Production*. Report 2004-2, EcoSanRes Publications Series. Stockholm: Stockholm Environment Institute. http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR2web.pdf

- World Health Organization (2006) WHO *Guidelines for the safe use of wastewater, excreta and grey water*. Can be downloaded from: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html



Chapter 4

Case Studies of Sustainable Sanitation Systems

Editors: Bogdan Macarol & Peter Ridderstolpe

INTRODUCTION

Sustainable sanitation can be defined as sanitation that protects and promotes human health, does not contribute to environmental degradation or depletion of the resource base, is technically and institutionally appropriate, economically viable and socially acceptable (as discussed in Chapter 3). Thus, the term sustainable sanitation is related rather to the functions fulfilled by the sanitation system than to any specific sanitation technology.

There are many different technical options for sustainable sanitation, and the choice of technical solution depends on the local conditions. To illustrate the variety of options available, five case studies of sustainable sanitation systems are presented in this chapter. The case studies range from low tech to high tech solutions and from source separating systems to end-of-pipe technologies.

All CEE countries were asked to contribute, and three of them – Hungary, Slovenia and Ukraine – presented case studies. As sustainable sanitation has a long tradition in other European countries, Global Water Partnership CEE invited Germany and Sweden to present cross-sectional reports about the development of sustainable sanitation in their circumstances.

CONSTRUCTED WETLAND SVETI TOMAŽ, SLOVENIA

Bogdan Macarol

Introduction

New environmental directives fulfilling the EU requirements have brought up serious questions concerning wastewater treatment in Slovenia. The treatment is often insufficient, especially in settlements with less than 2000 inhabitants. In many places the discharge of sewage causes environmental damages and infections to people.

In Slovenia the value of wetland ecosystem for wastewater treatment has not been recognized until recently. The development of environmental technologies such as the Constructed Wetlands (CW) started 20 years ago. An interesting concept developed was a mechanical system for exchanged water flow in the vertical beds and a system combining vertical and horizontal flow within one bed in the systems as well as cleaning sumps was introduced. Today, thanks to their continuous development and efficiency, these systems represent a "greening" trend in the country's environmental engineering with over 63 CW designed and constructed.

In Slovenia there are 143 public municipal wastewater treatment plants (WWTPs) constructed for less then 2000 inhabitants. Nine of them are natural treatment systems (CW type). One of such is the system constructed in Sveti Tomaž.

Planning and implementation process

Settlement Sveti Tomaž is located in northeastern Slovenia in the Prlekija region and Municipality of Sveti Tomaž. The nearest town Ormož is 12 km away. Before 2001 the only solution concerning municipal wastewater was the use of individual cesspits systems. In that time there was no sewerage system.

Project of WWTP Sveti Tomaž started in October 1999. The choice of system was made from an official invitation for tenders initiated by the Communal Company Ormož, the local public organisation responsible for environmental protection. The winning proposal was a constructed wetland concept developed by Limnos company, which was built between April and September 2001 and put in operation in October 2001 (Figure 4.1). CW Sveti Tomaž was constructed for 250 inhabitants populated in Sveti Tomaž.

Figure 4.1. Constructed Wetland Sveti Tomaž

System design

The WWTP was designed for an average daily flow of 38 m^3/d of waste water and covers the surface area of 700 m^2 (39 m length x 18 m width). The system consists of septic tank as a pre-treatment and four successive beds (filtration bed, two treatment beds and polishing bed, see Figure 4.2).

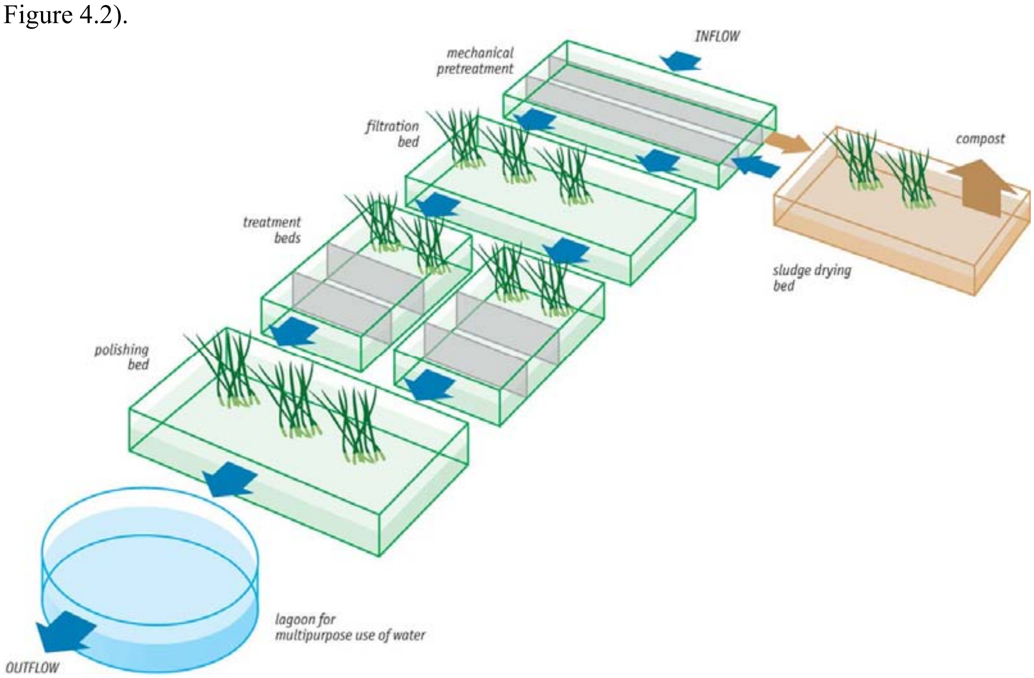


Figure 4.2. A sketch of the Constructed Wetland. The system consists of septic tank as a pre-treatment and four successive treatment filter beds.

Depth of the CW varies from 0.5 to 0.8 m, while the slope of the bottom varies from 0 to 1.5%. The whole system is waterproof and isolated by 2 mm thick HDPE foil and filled with the substrate. The medium layer consists of a mixture of different materials (fine sand, sand, gravel and small amount of soil, used only together with plants) specific chosen in portion and grain size. Hydraulic porosity of mixed media is 10^{-3}m/s and hydraulic load is 5.3 cm/d.

After the excavation of beds, non-permeable foil placement, installation of drainage tubes and input of the media, the beds were initially planted with 7 rhizomes and clumps per m^2 of *Phragmites australis* (Common Reed) and *Carex gracillis* (Sedge) in autumn.

The flow in the CW Sveti Tomaž is subsurface. The described constructed wetland uses only gravity for its operation, so the system operates without any additional machinery and electrical equipment. A section of the constructed wetland is given in Figure 4.3.

It is important that water is well pre-treated before led to treatment in the wetland, otherwise the pores in soil media soon clog. The treatment takes place in micro ecosystems around soil particles and the roots of the emergent plant. The soil media is substrate supporting the plant growth, but also create surface for micro-organisms. Bacteria decompose (mineralise) organic matter to carbon dioxide and water. The slow transport of oxygen supply in water is a strong limiting factor for mineralization and therefore, the process is slow. However, some oxygen is released to water by the roots from plants but this supply has proved to be minimal[29]. Instead plants contribute in treatment by assimilate nutrients and other elements into their biomass. They also remove water by transpiration. The sucking of water creates a movement of water in micro pores and the interaction between bacteria and water near tiny roots has been suggested to benefit treatment.

Lack of oxygen make nitrification rate low, but the nitrate produced is easily denitrified and released to the atmosphere as nitrogen gas. Phosphorus is sorbed to media by different mechanisms, such as ion exchange, flocculation and precipitation. Phosphorous removal rate decrease with time and depends much on the content of iron, aluminium, and calcium in media. The metal content in municipal waste water is usually low and does not represent greater difficulties in purification procedures. No bioaccumulation of heavy metals in plant tissue has been observed to have a negative effect on plant growth. The micro-organisms and natural physical and chemical processes are responsible for approximately 80–90% of pollutant removal. If harvesting plants remove about 10-20% of nutrients. Constructed wetlands reduce faecal indicators by 95–99%.

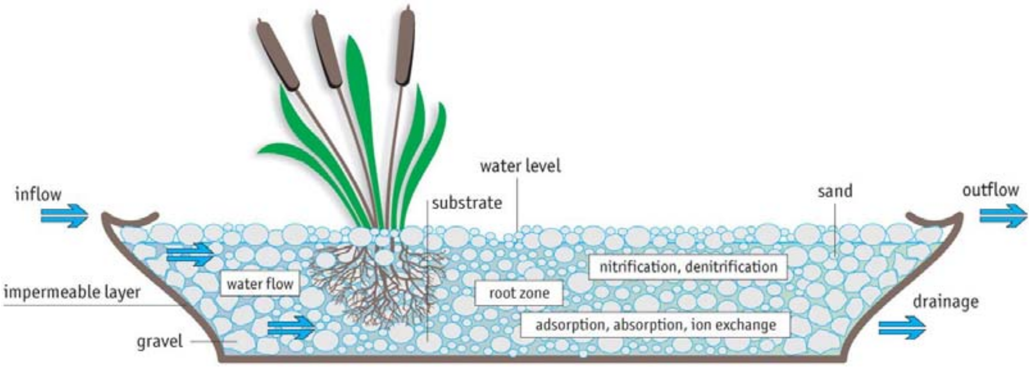


Figure 4.3. Constructed Wetland from section

Results and experiences

According to Slovenian regulations written in "Decree on the emission of substances in the discharge of waste waters from small urban waste water treatment plants (OG RS, 103/02, 41/04) it is obligatory to monitor systems between 200 to 1000 PE every two years. Therefore, an inflow and outlet well was constructed for water sampling. The efficiency of CW is controlled by Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD_5) analyses. The analyses done in April 2004 and July 2006 by the Institute of Environmental Protection under the Institute of Public Health Maribor are presented in Table 4.1. As the sewage is easily degradable, high removal efficiency was expected. Analysis also indicate high removal capacity (COD 77–93%, BOD_5 94–95%).

CW Sveti Tomaž has many advantages such as low construction costs (CW costs were 50.000 Euro) and operation costs (CW needs 200 Euro per month), simple installation and maintenance, reduced hygiene and environmental pollution risk, and was, due to "nature" look like appearance and with no noise and bad odour, quickly accepted in local public.

[29] Brix, H., 1993.

Table 4.1. Removal efficiency for selected parameters of CW Sveti Tomaž in April 2004 and July 2006.

Parameter		**April 2004**	**July 2006**	**Discharge limits in Slovenia**
COD (mg/l)	Inflow	130	400	
	Outflow	<30	<30	150
	Efficiency (%)	77	93	
BOD_5 (mg/l)	Inflow	50	150	
	Outflow	<3	<3	30
	Efficiency (%)	94	98	
Suspended solids (mg/l)	Inflow	25	120	
	Outflow	<10	<10	
pH	Inflow	7,5	7,3	
	Outflow	7,3	7,3	

In Slovenia the building of CW seems to be a very reasonable solution for:

- Settlements under 2000 inhabitants.
- Scarcely populated areas, where the communities have no wastewater treatment systems.
- Areas where water treatment includes only mechanical treatment level.
- Places where a tertiary treatment is non-existent or insufficient. (especially in places marked as drinking water resources, for example groundwater water).
- Karst area (44% of Slovenia surface) where the pollution of ground water represents a high risk for the population. At the same time, due to a lack of water, water reuse and quality control is essential.
- Tourist areas (for example camps, hotels and tourist attractions) where high loading rates in high season seriously overload water self-cleaning abilities.
- Areas with special natural importance (36% of the state surface is recognized as Natura 2000 area). As CWs are nearly unnoticed in natural environment and contribute to its greater diversity, their use is highly appropriate in natural parks.

Further development of CWs is focused on optimizing the treatment with the reduction of surface area based on different designs, substrate, and combinations of plants and natural microbes.

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WASTEWATER IRRIGATION OF POPLAR PLANTATION – A SUSTAINABLE SOLUTION FOR SMALL SETTLEMENTS WITHOUT SEWERAGE SYSTEM IN HUNGARY

Viktória Marczisák

Introduction

In large towns in Hungary drinking water supply was organised already 150 years ago. This improved living conditions but caused a new problem – odour and infections from sewage water. The first "sewerage legislation of Pest" was made in 1847 but it took almost 50 years to start building the first sewer system in Budapest.

The first sewerage works began to operate in the bigger towns in the beginning of the 19th century and at the same time, sewer systems were constructed in most municipal towns. Small towns and settlements still had simple septic tanks (cesspools) from which wastewater was allowed to percolate into the soil. After World War II the development of sewer systems and treatment plants continued. New sewage systems where constructed to separate storm water from wastewater. Today about 70% of the households are connected to a sewer system and plan is to increase that number to 90% by the year 2015.

The situation regarding the treatment of the collected wastewater was very bad in the 1990s. Most wastewater was treated mechanically, or not treated at all. The produced sludge was disposed in nearby dumping sites and very little was used in crop production. Today, the main part of the collected wastewater is treated to secondary level (mechanically and biologically). However, the sludge management is still a big problem.

Poplar irrigation (forest irrigation) and other natural wastewater treatment methods

During the last four decades various natural wastewater treatment technologies have been applied. Today there are about 125 such system in operation[30]. Most common are irrigation of poplar forests but pond systems and constructed wetlands (though only the root zone concept) are also quite common. Many of these plants also treat wastewater from the food industry.

In Hungary the "forest irrigation" method is called "poplar irrigation". This is because for decades the poplar has been the main type of tree used for wastewater irrigation. Today other trees are also used for irrigation, e.g., the osier (*Salix viminalis*). The first wastewater irrigated poplar forest was built in Gyula in 1969. It received a mixture of municipal wastewater and food industrial wastewater. The poplar system was built after the existing mechanical pre-treatment (sedimentation) and biological treatment (trickling filter). Effluent from the biological step was collected in a storage basin from where it was pumped through an underground pipeline to the ditch system of the forest. Water was applied all year round on a rotation basis.

Using the experiences gained at Gyula several poplar plantations have been built throughout Hungary, typically in the arid regions of the country. Although there were different problems (e.g., soil and groundwater pollution), mainly at the plants built earlier, these were caused by design, construction and/or operation failures due to lack of experience. However, during the last few decades the poplar forests have proved to be very efficient and reliable in terms of

[30] National Environmental Office with the cooperation of the regional Environmental Inspectorates in 2002, Budapest Technical University in 2004

pollution control and reuse of water and nutrients. Pollutants from wastewater are transformed in soil and use nutrients and water in biomass production. Wastewater irrigation makes the poplar grow well even in poor soils and the quality of trees does not decrease due to the irrigation.

Typical design of wastewater irrigated poplar forests (in Hungary)
The forests are irrigated with "normal" wastewater (WC and greywater) but in some cases septic waste is treated. The first component of the system is typically a sedimentation tank or pond that removes coarse particles and buffers the water. Pre-treatment is important especially if septic waste is handled where coarse particles like fibers and plastics prevail. The micro-organisms in the soil will mineralise organic materials.

Normally water is distributed by flooding (water runs by gravity into ditches between the tree lines). Some systems use spray (sprinkler) irrigation. Irrigation by sprinkler distributes water uniformly to the trees but creates risks for spreading infections by aerosols and sometimes odour. In systems using flooding, irrigation takes place all year, even in wintertime when the temperature is less than –10°C. The ditches are not continuously flooded, but flooded in every other or every third week only. Therefore, if it is very cold usually this condition remains for no longer period than 1–2 weeks, and by or at next flooding time this frozen wastewater will melt and percolate slowly to the soil. Ditches should be designed and operated so that the pouring water in the ditches is isolated by ice cover and snow. (Remark: the conditions in other countries can differ from the Hungarian conditions, therefore local circumstances always have to be considered, and preferably experiments should be made.)

The wastewater is a valuable recourse for plant growth, quite well balanced in water, nutrient and organic matter. Thus trees grow fast and have a high capacity to assimilate nutrients. Light soil is favourable for poplar. In hard ground the willow tree thrive better. Other trees usable for irrigation in Hungarian (European) climate are: White poplar (*Populus alba*), Black poplar (*Populus nigra*), Trembling poplar (*Populus tremula*), European birch (*Betula pendula*), White willow (*Salix alba*), Osier (*Salix viminalis*), and Paludal oak (*Quercus robur*).

The most rapidly growing tree in Hungary is the osier (*Salix viminalis*). According to current experiences in Hungary, fast growing *Salix* plants have a capacity to remove 600–1.000 kg N/ha/year, twice as much as that of the poplar trees. In such high loads plants use only a part of the nitrogen, much is released to air (N_2, NH_3) and some to groundwater (NO_3). Water uptake is significant; up to 150 m^3/ha/day is transpired from field.

Biomass production is high. After the first year 8–10 t/ha/year dry matter can be harvested. After 3–4 years yields can reach 20–40 t/ha/year. It grows 3–4 metres in the first year, and after 3–4 years it could grow even 8 meters per year (if not harvested regularly)[31]. Normally not all the wastewater will be utilised by the trees. Some part will percolate to groundwater. Under the condition that irrigation is located, designed and operated properly, this percolating water will be clean and serve as a supply to the ground water reservoir. The advantage of the system is high treatment efficiency in terms of BOD and nutrient removal, and the economic value from the harvested trees. Using irrigated trees some part of the natural forest can be saved. Disadvantage of the system is that irrigation may increase the levels of pH, and the concentration of total N, P_2O_5, K_2O, Na, Mg, and heavy metals in the soil.

[31] Stehlik, 2003

The poplar plantation in Aparhant, Hungary

Aparhant is a small settlement (1200 persons) in the undulating and scattered populated country of the south-western part of Hungary. Almost all households are connected to a drinking water network operated by the local municipality. People use simple sanitation solutions (toilets with septic tank or latrines). Previously the septic waste was transported to the nearby (15 km away) wastewater treatment plant, to the nearby waste dumping site or even directly to streams. This illegal practice has caused serious environmental damage. Nitrogen content of the deep groundwater (200 m) used for drinking water supply has increased. Also the fish died in nearby fishponds. Therefore, the population of the village decided to improve the situation. The ambition of the municipality was to find an integrated solution where both public health and the environment could be improved in a low cost system. Creating local jobs and increasing the public awareness was also a target. Already in the beginning it was concluded that a sewer system would cost too much.

According to the environmental legislation in Hungary, at least three different treatment solutions always have to be designed, and at least one of them has to be a so called ‘natural wastewater treatment technology’. In a feasibility study submitted in 1997 the following four systems where described:

a) Pond system with vegetation, without artificial aeration (after pre-treatment the wastewater would flow to the pond, the vegetation of which can grow naturally, or can be planted; the effluent of the pond would flow to a surface water as recipient);
b) Pond system, the effluent of which would percolate through a sand filter (the soil would be the recipient);
c) Anaerobe pond with poplar irrigation and disposal (the treated wastewater would not be collected by drains in the poplar plantation but would percolate into the soil);
d) Conventional (artificial) biological treatment (SBR) and poplar irrigation and disposal (the treated wastewater would not be collected by drains in the poplar plantation but would percolate into the soil).

In each case, the water would be collected in septic tanks and transported to a pre-treatment process before the suggested treatment system. It was also suggested that the produced sludge should be composted and used in agriculture. The designer compared the different options, see Table 4.2.

Comparing the four possible solutions, the option C (anaerobe pond with poplar plantation) seemed to be the most economical considering investment and operational costs. Also considering the criteria of environment protection, this option seemed to be superior. Speaking for the C-option was also reliability and little demand of manpower.

From the feasibility study and the comparative consequence assessment the alternative (c) was proposed to the Environmental Inspectorate, which approved the proposal with additional suggestions. An implementation plan was carried out to develop and describe the modified alternative (c) in detail. Construction work began and in 2001 the system was taken into operation. Today 80 m^3 per day of septic waste is treated in the poplar forest – and root zone system. The solution is described in Figure 4.4. The irrigation ditch before flooding is shown in Figure 4.5.

Table 4.2. Evaluating table[32].

Evaluation issue	Max possible score	Varietes			
		A	**B**	**C**	**D**
Investment costs	80	60	40	80	10
Operation costs	100	60	40	100	80
Environment protection (aquatic environment, soil, air)	100	80	90	100	80
Technical level (within each system how up-to-date the chosen technology is)	20	20	15	20	20
Possibility of construction to be scheduled (to increase / decrease capacity according to needs)	20	15	20	20	10
Technological safety (possibility of failure of equipments, or possible problems affecting treatment, e.g. freezing of ponds in winter)	20	20	15	20	10
Area demand	20	10	10	10	20
Treatment demand (need for manpower)	20	20	20	20	10
Safety of balanced operation of sludge treatment (so as to avoid the need to deal with the sludge every day)	20	15	15	20	15
Total score	400	300	265	390	205
	%	77	68	100	59
Place		2	3	1	4

Experiences

A monitoring program follows the performance. Wastewater samples are taken regularly from the screening tank, from the effluent of the sedimentation tank, from the storing tank and after the root zone wetland. The soil sampling was made during trial operation (in 2000) in every month, since operation has started in every 3rd months. There are also monitoring wells controlling ground water quality, however the level of groundwater is too low to be sampled. The monitoring has proved that pollution of nearby fields, groundwater and fishpond has been stopped.

The removal efficiency in system is difficult to verify. Total nitrogen load is about 1200–1400 kgN/ha/year. (The forest was planned to be 1.6 ha here, but it is about 3–3.5 ha today). About 20–30% of nitrogen is probably removed by harvested crop and from grazing of sheep (Figure 4.6).

[32] after Stehlik József, 1997

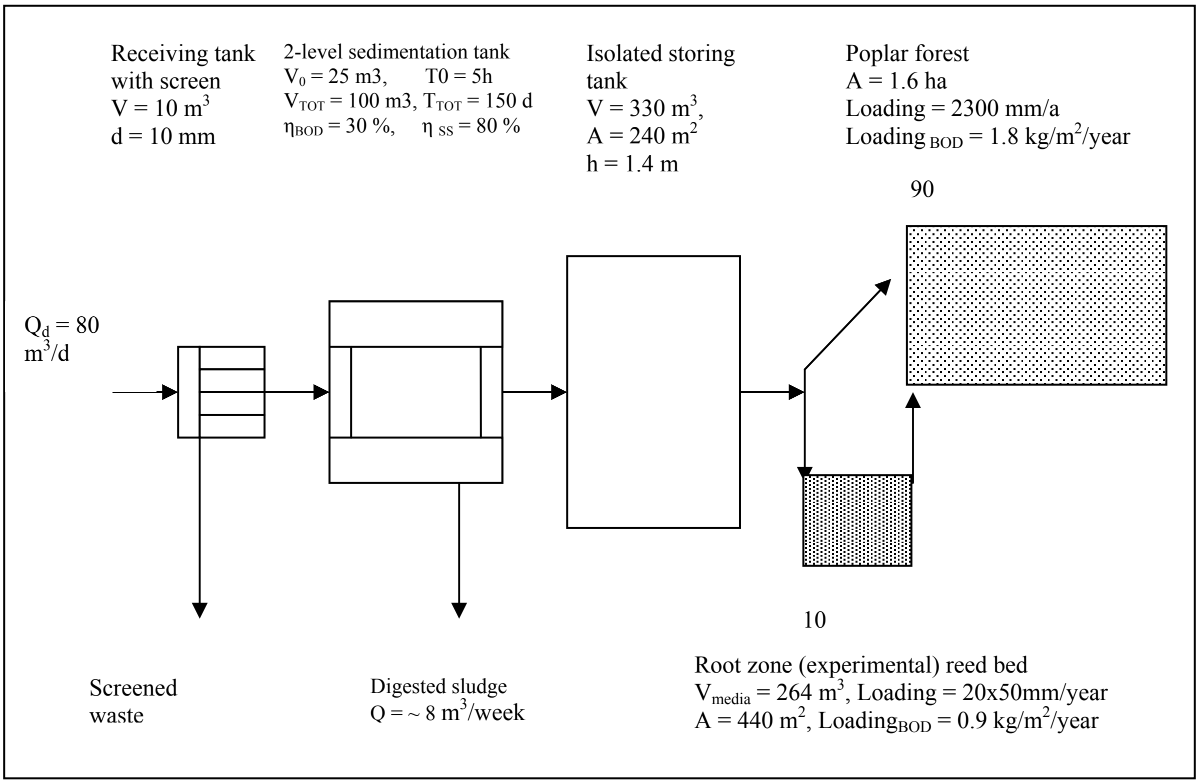

Figure 4.4. Principal sketch of the constructed system. Collected septic waste from households is transported to the receiving tank for screening. Pre- treatment takes place in a two-level sedimentation tank from which water is led to a sealed storage tank. From storage water is distributed by gravity to natural biological treatment units, the forest and the root zone wetland. Irrigation takes place year around and sludge is removed from sedimentation tank once a week.

Figure 4.5. Irrigation ditch before flooding.

Figure 4.6. Maintaining flock of sheep

Construction costs are 53 Euro/p.e. and operation costs 0.05 Euro/m^3. This is very low compared to traditional systems. Resident people did not have to pay for the construction. Instead the municipality collected funds from aid contributions, the municipality budget and different donors. The seedlings were free gifts from a forest company (promotion) and the inhabitants themselves planted the trees. The municipality has bought septic waste transporting vehicles, now operated by previously unemployed people. Their wages are paid from central aid and municipality budget, so this service for the public is free. Also the municipality has paid (using different state aids) for the construction of proper septic tanks for each house, while the inhabitants had to pay a symbolic amount only (20 Euro).

The poplar trees are utilized by the inhabitants (burning for heating) for free. The reed of the constructed wetland is cut every year, also utilized by the local population for different purposes. The consolidated sludge is transported to a composting place every 4th–6 th week. The composted sludge is used in the agriculture. The grass does not have to be cut between the trees, because the flock of sheep of the village carries out the "maintenance", saving costs of a few workers every year. The elementary school students have participated in tree plantation, and – in biology lessons – make measurements to learn about natural processes occurring in wastewater treatment.

The inhabitants are very satisfied with the wastewater treatment plant. Their environment has been improved, their health is protected and new jobs have been created for some unemployed people. The use of sludge trees, reeds are extra benefits. The experiences from the poplar plantation in Aparhant demonstrate a practical and affordable solution for beneficial environment, economy, unemployment and awareness of environmental issues for people with low-income levels.

Contact

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DRY URINE-DIVERTING SCHOOL TOILETS IN VILLAGES, UKRAINE

Anna Tsvietkova

Introduction

In Ukraine 95% of cities, 56% of settlements and only 3% of villages have a sewer (canalization) system. Only 1.4 million (8.8% of the rural population) use centralized wastewater services. The rest (14.3 million) of rural dwellers use pit latrines and septic tanks, which are usually out of control and become a source of nitrates and biological contamination of ground water.

In rural schools, lack of proper water supply and sanitation facilities is a common problem. If the school has a water supply and sewer system, the interruption of water supply results in the immediate break of wastewater system operation. Long (1–2 weeks or months) interruptions of water supply are a usual problem in rural areas. During the water supply interruption the indoors toilets connected to the sewer system are closed and schoolchildren use pit latrine. In Ukraine, 2 million schoolchildren study at 14,000 rural schools. For example, in Poltava region there are 30 schools among them 12 schools use conventional toilets, 5 schools have toilet and pit latrines and 13 schools use only pit latrines. Usually pit latrines are located 50–100 m from the school building and have no heating. Cold, dirty and old pit latrines are the problems for the children, which are out of attention of adults.

To find out a solution for these children a project “Cooperation for sustainable rural development: water supply, ecological sanitation and organic agriculture” was initiated by the NGOs: “MAMA-86” and Women in Europe for a Common Future (WECF).

School toilets in the villages Gozhuly and Bobryk

The aim of this project is to find out functional toilet solutions for schools and poor people in rural areas in Ukraine. The work has been carried out by a project group of NGOs in close cooperation with local communities. MATRA Program of MFA of the Netherlands has funded the project. Experts support has been given from Hamburg University of Technology (TUHH) that designed and supervised construction of the system built.

Considering the bad conditions and malfunction existing water- and wastewater infrastructure it was decided not to rely on a centralised waterborne system. Instead, the concept of dry urine diverting toilets (DUDT) was chosen. DUDT is an on-site solution not depending on centralised water and wastewater infrastructures; it needs no water for flushing and minimum water for operation (for cleaning of the toilet rooms and hand washing). DUDT diverts the urine from faeces at the point of origin and the two fractions are collected separately. The smell decreases and the quite small volume of faeces can be handled more conveniently. Composting reduces health risks of the faeces and nutrients and organic matter can be used for soil amendment. The urine is collected in an isolated tank. After some month of storage the urine is free from pathogens and can be used as soil fertiliser. Thus the hygiene and environmental problems connected with human excreta can be controlled and the excreta transformed into a valuable resource.

The village of Gozhuly is located 2 km near city Poltava in region Poltava. The population is 3600 inhabitants distributed in 1000 households. The people in the village get centralised water from some very deep artesian wells (200 m) but many small shallow wells are also used. The systems are old and canalization infrastructure has resulted in unsatisfactory service delivery such as frequent interruptions of the water supply, water loss and wastewater leakage.

There are about 500 children in the village but only 180 are school children. School is connected to WS and WW systems. Regular water interruption in water supply had resulted in the closing of the water flushing toilets and putting into operation outdoor pit latrine. Usually only teachers and children till 7 years old use the indoors flush toilets. All other schoolchildren use pit latrines (see Figure 4.7).

Village Bobryk located near city Nizhyn of Chernigiv oblast, is a small settlement with 400 resident people. The majority of Bobryk residents are pensioners. Only 41 children live in the village. There is no centralized water supply and wastewater infrastructure in the village. The people use wells and pit latrines.

Figure 4.7 The old school toilet in Gozhuly village: Outside (left) and inside (right).

Planning and implementation

One of the first initiatives in the project was to hold a seminar with representatives from the villages' authorities, school administrations and the people. On the seminars, WECF experts presented the ecological sanitation concept. The mayors and the school administration agreed to improve the sanitation facilities of the schools by introduction of the DUDTs.

In Gozhuly, a pilot project was started in July 2004, ecosan toilet was built during August–September 2004 and put in operation in October 2004. In Bobryk the ecosan toilet was built in July–August 2006 and it was put into operation in September 2006. Since toilets have been in operation the main operators and users are the Gozhuly and Bobryk school administrations.

Both Gozhuly and Bobryk use the "dry urine-diverting toilets" with separate collection and storage of the urine and the faeces. This technology provides dry composting of faeces and using of compost and the urine as organic fertilizers. Plastic squatting-pans and the traditional ceramic urinals (See Figure 4.9) equip the school toilets. Squatting-pans were selected instead of seat risers for hygienic reasons. The pans where bought and delivered by WECF. The technical documentation (business plan) for school toilets was made by local engineering agency. DUDTs were built by MAMA-86 branches in Poltava and Nizhyn with involvement of the local entrepreneurs-builder companies.

Gozhuly toilet consists of 3 double vault urine diverting toilets and one room with 3 waterless urinals and 2 urine tanks of 2 m^3 each (see Figure 4.8 and 4.9). This facility is built close to the school building with the entrance directly from school. 165 pupils (7–17 years old) use it. The tap water is used for hand washing and the greywater goes to the village sanitation system.

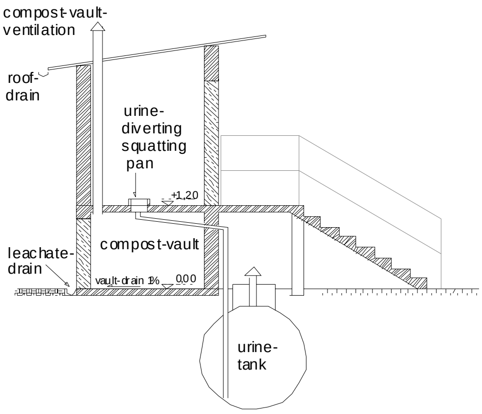


Figure 4.8. Gozhuly toilet consists of 3 double vault urine diverting toilets and one room with 3 waterless urinals and 2 urine tanks of 2 m^3 each. 165 pupils (7-17 years old) use the toilets (DUDT idea designed by TUHH)

In Bobryk, a new toilet room is built inside the school with urine diverting toilets and urinals. Under the floor, faeces are collected in a chamber under the floor. Urine is collected in a two-1 m^3 plastic tanks. Hand washing facilities have been installed with a simple greywater treatment unit near the toilet with drainage and filtration (see Figure 4.10 and 4.11). 36 pupils and 16 teachers use the facility.

Each toilet has 2 tanks (in Gozhuly there are 2 tanks of 2 m^3 each and in Bobryk – 2 tanks of 1m^3). One tank is in operation and the other is empty or used for urine storage. The time of urine storage is no less then 6 month, during that time most of the pathogens are killed or at least reduced. To empty the urinal tank the pump is used. In autumn 2006, the urine from Gozhuly toilet was used for the first time by a local farmer as nitrogen fertilizer in his garden.

The faeces are collected in the vault/chamber under the floor of the toilet room. After defecation, the faeces are covered with dry sawdust/dry soil or their mixture to minimise the water content and thus odour and flies. The vaults are easily accessible for caretaker. The composting-chambers have a sealed floor made from concrete. The vaults are used alternating in a 2–2.5-year rhythm. The volume for storage/composting in each chamber is 1 m^3. The floor has a slope of 1% to drain leaching waters.

Figure 4.9. New school toilet in Gozhuly village: outside (left), urinals (centre) and inside (right).

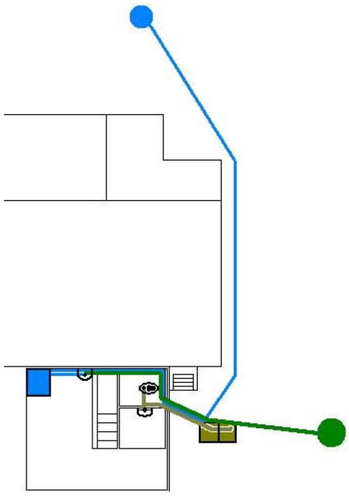


Figure 4.10. The water supply and greywater systems of the Bobryk School. 36 pupils and 16 teachers use the facility. (Drinking water supply market with blue colour, technical hand washing water supply – by green, greywater outlet – olive colour), designed by MAMA86-Nizhyn.

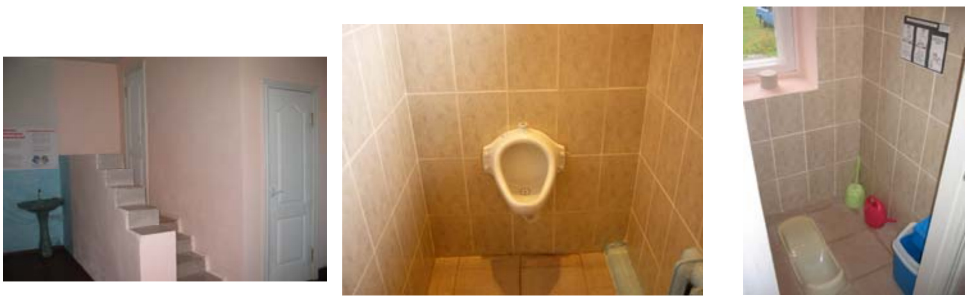


Figure 4.11. New school toilet in Bobryk village: outside (left), urinals (centre) and inside (right).

Results and experiences
After two years DUDT operation in Gozhuly School, the working vaults are filled only on 1/3–1/2 of useful volume. In Bobryk the container is used to facilitate the work of the caretaker work. During 8 months of operation the container with volume of 50 l was emptied 2 times, when it was filled on 2/3 part. The container content was removed into the special place for outside composting during 2 years. The caretakers have been carefully instructed on how to manage the ecosan toilets. Caretakers inspect and clean the toilets daily with soda and/or hot water. From time to time the faeces in the compost are mixed and covered with wood chips. The caretakers monitor the composting-chambers and the urine-tank. The environmental benefits of the new system can be summarized as follows:

- Very little wastewater is produced (no stopping and odour from logged water).
- Less water is used (no need for flushing).
- No discharge of untreated waste water. Minimum risk for contamination of ground water (nitrogen and pathogens).
- No toxic chemicals are used for disinfecting.
- Recycling of nutrients (urine and compost can be used as fertilizers).

Traditionally in Ukraine the school and public toilets are cleaned and disinfected by the use of chlorinated reagents. In ecological sanitation, other methods are used e.g. urinals are cleaned with hot water or a vinegar solution. The new toilet solution simplified and minimized maintenance of the sanitation facilities. Previously schools old pit latrines and stops in wastewater canalization caused many problems. Urine has been successfully used as fertilizer in crop production, but still there is little experience on using the compost material.

Schoolchildren use comfortable, clean and hygienic inside sanitation facilities instead of cold dirty pit latrines. A survey made for Gozhuly showed that 75% of children have easily adapted to the new system and are happy with toilets. Education is a key factor and school children teach the system to their parents. Thus learning's are spread to adults and the technique will hopefully be disseminated. Gozhuly toilet costs near 10 000 Euro for construction. Maintenance costs are low (cleaning and hygienic materials and tools). In Bobryk toilet costs €2900. Materials for individual dry toilet costs in average €350.

For scaling up of this technology in Ukraine further development is needed. The design should be adapted to local conditions (climate, market, building and hygiene standards, etc.). Technical improvements and instructions and training's for entrepreneurs are important for introduction of the technology to a local market. Special attention must be paid to solving problems with smell. Other problems experienced have been freezing of urine and water in pipes and urine collecting tanks. To solve these and other problems more testing and research is needed so that appropriate instruction for installations can be worked out.

Legalization and the regulating system must support DUDT systems. Business plan on building school DUDT has to be approved by the authorities responsible for the wastewater treatment. In the permission procedure there are several authorities involved: the local SES (Sanitary and Epidemiology Station), the authority on fire security, architecture and building, education, municipality and others. In Ukraine the legally accepted sanitation solution for school is conventional centralized (connection to local sewer and WWTP) or decentralized (cesspool or pit latrine) solutions. Development of the Sanitary and Epidemiology legal frame for *"Ecological sanitation" is* needed for the safe usage of human excreta and application of ecological sanitation technologies for social/public buildings (schools, hospitals, summer camps, public places).

SUSTAINABLE SANITATION AND WASTEWATER MANAGEMENT IN SWEDEN – A CROSS SECTION OVERVIEW

Peter Ridderstolpe

Developing sanitation and wastewater management in Sweden
In the early period of urbanisation, the rural tradition to collect and use human excrement in agriculture was developed and well organised. The shift between 1800- and 1900-century meant a change from reuse to disposal and in many towns drainage systems were constructed to transport storm water and wastewater to the nearest recipient. After the second world war treatment started to be a common practice. During a short period between 1970 to 1985, treatment plants were built out for primary, secondary and tertiary treatment for almost all people in Sweden. This large expansion of treatment system was possible due to a legislation that allowed municipalities to force households and industries into sewage systems and charge them for using the service, but also due to great governmental subsidies to construction pipe systems and treatment plants.

In the early 1990s management of sludge appeared as a growing problem, when the sludge was not accepted for recycling to agriculture any longer. The food industry didn't want to by sludge fertilised crops due to its potentially high levels of heavy metals, toxic organic elements and pathogens. During this period the high costs and energy need for upgrading and operating wastewater treatment was also questioned. As a consequence an interest for alternative and more "ecologically adapted" technologies was developed [33].

The economical situation during the last decade (low interest rates, relatively low cost for energy and chemicals and high labour costs) has favoured the traditional large scale and linear systems. Nevertheless, in 2006 new guidelines for small-scale wastewater systems were published by the Swedish Environmental Protection Agency. The guidelines state requirements on health protection, environmental protection and recycling of nutrients to be fulfilled by the wastewater systems. The implementation of these new guidelines will hopefully drive for a more holistic thinking in planning wastewater systems. Clear is that increasing costs for electricity and oil drive for more energy saving systems. Increasing costs for pumping and maintaining pipe system has made decentralised thinking more acceptable. Today municipalities especially in rural areas start to be more interested in onsite or cluster systems and a there is a new born interest in natural systems. A tendency is also that the agricultural sector is more interested to handle and use waste water fractions. The growing market for bio-energy products may explain this but also the increasing costs for artificial fertiliser.

Precipitation ponds
Wastewater treatment in ponds has been used for several hundred years around the world. In Sweden, pond systems were popular during the first era of modern wastewater treatment, due to low costs, simplicity and capacity to treat large quantities of wastewater. Today there are about 100 precipitation ponds in operation in Sweden.

Design and dimensioning
When planning new systems, the sedimentation volumes should be divided into several narrow ponds. One extra cell should be built so that one pond can be taken out of operation during de-

[33] Etnier C and B Guterstam, 1991

watering and sludge removal. Planning for 5–10 days retention time for sedimentation is recommended. Course particles must be removed before adding coagulants, pre-treatment by screen or grid is sufficient.

The chemical coagulants, which can be lime or salts from aluminium or iron, flocculate and precipitate particles and phosphorous from water. Aluminium or iron based coagulants are more easily managed than lime. They can be used as liquids and added directly into a pressurised pipe entering the bottom of sedimentation ponds. Lime remove pathogens and make sludge valuable as fertiliser. Problem is that sludge from lime is heavy and easily clogs pipes and vaults. Pipes, wells and vaults must be design from that and constructed accessible for service.

Box4.1: The precipitation pond in Funäsdalen

Funäsdalen is a typical skiing tourist resort in a mountainous are of northern Sweden. The number of inhabitants varies from about 1000 to 4000 people. Hydraulic load is around 400 m^3/person but flow peaks arise during rain and snow melt. The plant built in 1987 is owned by the municipality and use slaked lime as coagulant. Flow variations are buffered in a first 2400 m^2 pond from where it is pumped to small precipitation ponds followed by a last 2 800-m^2-sedimentation pond. Plastic baffles are used to hinder short cut flows. Lime addition of 600 g/m^3 raises pH to about 12 keeping outlet phosphorous levels around 0.5 mg/l (inlet 6.4 mg/l). Sludge is removed from the small ponds every year. The municipality likes the facility because it is cheap, easy to maintain and efficient.

Experiences and results

Precipitations ponds have proved to be very tolerant for flow variations and periodical stopping in chemical addition. Treatment performance is high and stable year around. BOD removal efficiency is about 70–80% (micro-algae production in summer explain the quite low figure). Phosphorous removal varies with amounts of added coagulants, but use to be around 80–95% Nitrogen removal is high (50–75% volatisation of ammonia and bacterial transformation of nitrogen to nitrogen gas.

When using lime, the pathogen removal is very high due to high pH reaction (pH 10.5–12). Draw backs include ammoniac stripping and large amounts of sludge produced. On the other hand, sludge produced from lime is valuable as a soil amendment, both because of pH effect and content of plant available phosphorous. Aluminium and iron are more convenient to manage, but less efficient for sanitation and results in sludge less suited for recycling.

Read more:

- Hanaeus, J, 1991, *Wastewater Treatment by Chemical Precipitation in ponds*, Dr Th, Div. Sanitary Engineering, Luleå, Sweden. Summary available at: http://epubl.luth.se/avslutade/0348-8373/95/index-en.html
- Johansson, E, et al, *Fällningsdamm och biodamm (Precipitation pond and algae pond),* .English summary. http://vav.griffel.net/filer/VA-Forsk_2005-18.pdf

Forrest irrigation
Wastewater irrigation is a common practice all over the world. In Europe, many sewage farms developed in the middle of the 1900th century. In Sweden, the use of wastewater for irrigation met a renaissance during the 1990s and several forest irrigation systems are in operation today. Most of them are found in the south of Sweden, as post-treatment for use in summertime.

Salix-irrigation is the most investigated and used. Meadow trees are in general more appropriate than conifer trees, but investigations from the northern part of Sweden nevertheless prove that moderate irrigation double or triple the production of furs and pines, thus making the investment in irrigation system economical.

Forest plantations are easier to irrigate than grasslands since the extensive roots-system of trees can compensate for uneven distribution of water and nutrients. The challenge for environmentalists and engineers is to design and operate these systems without jeopardizing sanitary conditions.

Box 4.2: Forest irrigation in Kågeröd

Kågeröd is a small town of 1500 people in Southern Sweden. Wastewater is collected and treated in a wastewater treatment plant with activated sludge followed by chemical precipitation. In 1994, a 13 hectare big field of Salix was established. Tree years later, irrigation started with water taken out from the treatment plant after the activated sludge process. Forrest growth and environmental impacts has been carefully monitored. Wastewater load of 6 mm/d gave the highest yield (10–13 ton TS/hs y). Loads three times the evapotranspiration rate (12 mm/d) and 175 kg N/ha did not impact biomass production negatively and no groundwater contamination was observed. Municipality is satisfied with the system, and believes that wood production, reduced costs for chemicals and sludge management compensate for the cost of irrigation.

Design and dimensioning
When dimensioning, the amount of irrigation should be accommodated to plant needs of both water and nutrients. Annual biomass production reach 10–12 tons dry matter/hectare in wastewater irrigated Salix, thus 7–10 kg phosphorus and 40–70 kg nitrogen/ hectare is extracted from the system annually in harvested biomass. Large fields should be divided into parcels (each cell 1–3 hectare big) where distribution is individually regulated. Automatic magnetic valves controlled by a computer program shift pumping time and resting between parcels.

Sprinklers, drip-irrigation and flood-application have been successfully used. Flood-application is tolerant for particles in water, while drip- irrigation urges highly clarified water. On the other hand, drip irrigation allows for very exact distribution. In Sweden, the irrigation period comprises maximum 7 months/ year. During periods when irrigation is not possible (due to low temperature or heavy rainfall) water must be stored or treated by other means.

Experiences and results
Forests irrigation has been found to be a cheap and efficient method for treating and reutilizing wastewater and its nutrients. Land availability, appropriate soil and hydrological conditions as well as the market for harvested biomass are important parameters when considering the

technique. Feasible methods for treatment during winter are for example chemical precipitation ponds or open soil filter beds. Careful planning, design and operation are required in order to manage the sanitary risks.

Read more

- Carlander, A. Stenström T-A., Albihn, A., Hasselgren, K. (2002) *Hygieniska aspekter vid avloppsbevattning av Salix (Sanitary aspects of wastewater irrigation of Salix)* English summary, http://vav.griffel.net/filer/VA-Forsk_2002-1.pdf
- BioPros, http://www.biopros.info/ Solutions for the safe application of wastewater and sludge for high efficient biomass production in Short-Rotation-Plantations
- Laqua Treatment: http://www.laqua.se/

(Vertical) Soil filter systems

Using the soil as media for wastewater treatment is the eldest and probably most commonly practised method in the world. Soil filter systems use the soil as a bio-geo-chemical reactor, where suspended solids are strained and adsorbed, organic matter is mineralised and phosphorous are flocculated and precipitated into minerals. In Sweden, sub surface vertical soil filters have been used as standard treatment for single households for the last 30 years. Around 400,000 such systems are in operation. In cluster systems, open sand filter beds are common.

Box 4.3: An open sand filter in Lagga

Lagga is a small village in Southeast Sweden. All 50 houses are connected to a centralised waterborne system upgraded in 1998. An open sand filter was chosen before a traditional package treatment plant, since the natural system was considered more reliable and equally efficient. After pre-treatment in a septic tank, water is pumped to the filter bed and distributed by vertical pipes. The system has worked without technical problems and maintenance costs are low. Personnel visit plant once a week. No chemicals are used, little electricity is consumed and sludge production is minimal. After treatment, levels of SS, BOD and bacteria are beneath requirements. A pond system works as post-treatment from which water infiltrates and evaporates.

Design and dimensioning

A soil filter must be designed and dimensioned to transfer all organic matter present in the water (BOD) to carbon dioxide and water. Thus no sludge is accumulated in the soil. Pre-treatment is essential, and normally solids are removed by sedimentation and floatation in a septic tank. In larger systems, ponds (that also serve as buffer magazines) are often used for pre-treatment. Most important for efficient treatment is that water is allowed to seep through the soil volume in an unsaturated flow. Water should flow vertically through the tiny pores while the large ones will hold air, providing oxygen for the heterotrophic (composting) micro-organisms. Natural soils can be used if soil property allows and safe distance exists to the ground water or bedrock. If natural conditions are not adequate sand filter is chosen. Particles in soil media should be round and a diameter around 1 mm. Media must be persistent. For example particles should not weather. Tail fraction (particles less than 0.1 mm) should never exceed 10%.

Most soil filters in Sweden rely on gravity. In larger systems, a pump is used for water distribution. Sand filters are constructed with drainage layer in bottom. Large beds should be divided into small parcels to which water could be applied individually. A new concept from Norway use nozzles for water distribution, which allows for very uniform water distribution even on a course filter media. Using the spray technique and coarse filter media about ten times higher load of wastewater can be accepted compared to was is possible in a conventional infiltrations or sandfilter system, see table 4.3

Table 4.3. Soil filters are dimensioning from load of BOD and water. The following figures can be used as a rule of the thumb when dimension vertical filter systems. (Hydraulic loads should be calculated from mean daily flow during a maximum week. Figures are relevant for normal septic tank effluent with BOD level around 200-350 mg/l).

Infiltration in natural soil:	30-40 mm/d,
covered sand filter bed (using gravity)	50-60 mm/d
covered sand filter bed (using pump)	60-80mm/d
open sand filter bed	80-120 mm/d
Norwegian spray (using 2-6 mm leca as media)	250-500 mm/d

Experiences and results
Vertical soil filters are robust with a high and stable treatment capacity. Removal of bacteria and virus is better and more reliable than in treatment plants. Vertical soil filters offer limited recycling of nutrients if used by themselves, but combined with *e.g.* diverting toilet systems, direct precipitation of phosphorous or summer irrigation they offer excellent options for sustainable sanitation.

Treatment performance is generally 90–99% removal of SS and BOD, 30–60% reduction of P (when using silicate sand from alluvial deposits, since soil contents of aluminium and iron have a great impact on P-removal) and 30% reduction of tot-N (70% nitrification). The removal of pathogens is more than 99%.

Read more

- USEPA, 2006 (1980) *Onsite Wastewater Treatment Systems Manual*, http://www.epa.gov/ord/NRMRL/Pubs/625R00008/625R00008.htm
- Ridderstolpe, P (2004) *Introduction to Greywater Treatment*, Ecosanres, http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR4web.pdf

Urine diversion

Sanitation based on latrines with or without urine diversion has a long tradition. Today source-separating systems have met a renaissance, not only because the systems have proven to be affordable and easy to manage, but also because they have the potential to secure a high level of public health protection, environmental protection and recycling. In Sweden, the development and research on urine diverting systems was intensive in the beginning of the 1990s. Today, urine diversion is used both in combination with dry collection of faeces and in waterborne systems. Several toilets (also in porcelain) are available on the market. Much knowledge has been reached on design, maintenance and the safe management of faeces and urine in agriculture. About 135,000 urine-diverting systems are in operation, most are dry systems.

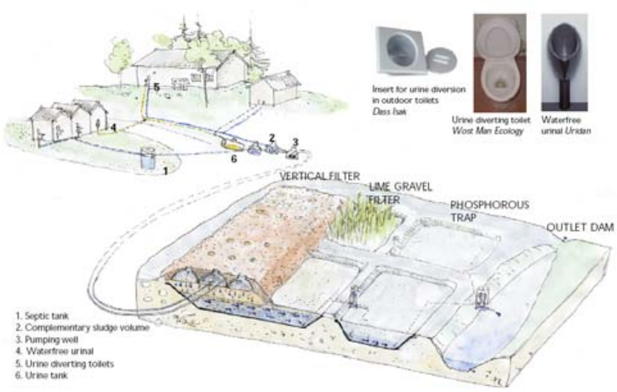
Design and dimensioning

Storage volumes are usually dimensioned for 1 year for urine and 3-4 months for faeces. A normal person excretes about 1000 gr. urine and 150 gr. faeces per day. It's essential that urine is kept sealed from air all the way from collecting to distributing to field. Faecal matter is collected in a sealed compartment, allowing air to be sucked out from the toilet room, to a ventilation duct entering over roof. The wastewater produced in dry diverting toilets systems (the greywater) is almost free from faeces. Thus it pose a minor risk for environment and public health. Still it has to be treated to remove particles and organic before brought back to nature. Toilet diverting system reduced significantly amount of wastewater why treatment cost is reduced.

Experiences and results

Urine diverting dry toilet systems has proven to be comfortable, hygienically and environmentally friendly solutions with high nutrient and water recycling potential. Compared to other systems with similar performance, urine diversion dry toilet systems are the most cost efficient. Urine diversion can also be applied in waterborne systems with significant benefits for environment and recourse conservation and sometimes costs.

Box 4.4: Urine diversion at the roadstop in Ångersjön



A sanitation system with waterfree urinals and double flush toilets was built in 2003 for an existing road stop with a public toilet, a restaurant and shop on the E4 highway. Many thousand people per day may use the facility during summer while very few persons visit in wintertime. Urine is collected in a tank and then used as fertilizer by local farmers. Wastewater is pre-treated in a septic tank and pumped to a constructed soil filter where water is distributed by spray nozzles. Phosphorous is then absorbed in horizontal filters with calcium rich reactive media. Carefully monitoring prove that the urine diversion contributes to 40% of P and N removal. Overall the treatment capacity is 97% BOD-removal and 90% and 65% reduction of P and N, respectively. Bacteria are reduced by 99.99%. Performance is stable irrespective of temperature and the great flow variations. Operation is simple with low maintenance costs. Sludge and urine are removed by a vacuum truck 2-3 times/year.

Read more

- Kvarnström, E et al. (2006) *Urine Diversion: One Step Towards Sustainable Sanitation.*
- http://www.ecosanres.org/pdf_files/Urine_Diversion_2006-1.pdf

ECOLOGICAL SANITATION IN GERMANY – SOURCE SEPARATION SYSTEMS

Ralf Otterpohl and Marika Palmér Rivera

Introduction

In Germany, over 95% of the population is connected to central sewage systems. Therefore, the development of sustainable sanitation solutions has focused on urban areas. Earlier, source-separating sanitation systems in Germany consisted of traditional dry toilets. Several problems with large chamber composting toilets (without urine-diversion) installed in multi-storey houses, including transfer of noise in the toilet pipes and problems with reuse of the leachate from the composting toilets, made these systems unpopular. TUHH (Hamburg University of Technology) and Berger Biotechnik, Hamburg, are now converting some of these to urine diverting dry toilets with vermicomposting (requires controlled moistening). The space requirement is a lot less and urine is far easier to reuse than the polluted leachate of the old type of composting toilets.

Development of more high-tech source-separating sanitation systems started in the early 1990s. The aim was to develop systems with circulation of nutrients, energy production and less pollution. Systems with separation of blackwater were developed since they are more easily adapted to urban settings. Today, the source-separating systems generate a lot of interest within the research community, but are not yet widely known by the public.

Blackwater separating systems - separate handling of toilet waste and greywater

The starting point of the blackwater separating systems is the major difference in concentrations between blackwater and greywater. Blackwater, if collected with little dilution, has a high content of pathogens as well as nutrients, but the produced volume is very small. Greywater has a low content of both pathogens and nutrients, but is produced in large volumes (see Figure 4.12). By not mixing these two fractions, treatment and recycling of nutrients can be more efficient. Several different types of blackwater systems are being developed in Germany. Below, the vacuum-biogas concept and the blackwater/brownwater loop concept are described.

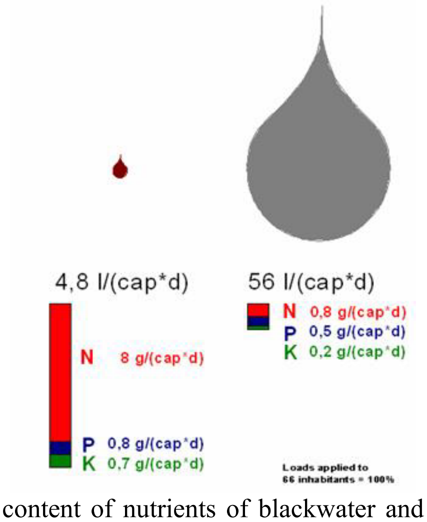


Figure 4.12. Volumes and content of nutrients of blackwater and greywater from a vacuum-biogas system in the residential area Flintenbreite, Germany.

The vacuum-biogas concept was developed by the German company Otterwasser and first published by Ralf Otterpohl in 1993. The blackwater is collected by a vacuum system and led to a digester which produces biogas and liquid fertiliser. Greywater is treated separately. For the system to be cost-efficient it requires a minimum size of around several hundred people. The concept works better where people live closely, in multi-storey buildings. After the first installation in Flintenbreite (described in Box 4.5), the technology is now well developed and similar systems with further functions are under development in e.g., the Netherlands, Hamburg and Shanghai, China. So far the experiences are good and the acceptance among users high. The Berlin Centre for Competence Water in Berlin (BWB / VEOLIA Water), has done a large scale research implementation of a urine diverting vacuum system into an office building and several flats. In the same project a further development of the Lambertsmühle concept (see below) was realised. KfW, the huge German development bank, has installed a vacuum-toilet system in a large office building.

The loop for toilet wastewater to toilet flushwater (the blackwater loop or loo-loop concept) was invented and patented by Ulrich Braun, Hamburg. This system makes water toilets independent from freshwater supply and produces a treated liquid with flow and concentrations like urine.

For new construction and complete reconstruction, this system can be significantly cheaper than conventional ones and reduce freshwater demand to 10 litres per person and day. The first installation worldwide of the blackwater loop was done at Hamburg University of Technology in 2005 with a design capacity of around 20 people. The first commercial installation will take place in the city of Ahlen, Germany (described in Box 4.6 below). Projects with the blackwater loop in dry areas in the Middle East are being planned.

Another version of the loop, which has not been built yet, is the brownwater loop, where urine diversion is added to the system. The disadvantage of this system is the extra piping needed. One of the advantages is that a smaller digester for treatment of brownwater (faeces, toilet paper and flush water) can be used compared to treatment of blackwater.

The possibilities for application in the CEE countries of the blackwater systems described here depend on the context. They are high-tech systems, which are feasible where there is enough money and technical skill. In rural areas and for small settlements, dry toilet systems are preferred.

Urine-diversion with flush sanitation

Urine diversion was re-discovered in Sweden around 1990 and the development of urine diverting systems in Germany is based on the Swedish experiences. In 1996, the German company Otterwasser added brownwater treatment to the urine-diverting concept in a two-chamber separation unit (the 'Rottebehälter'-system). This concept was applied in the Lambertsmühle mill described below.

A similar system to that in Lambertsmuehle also designed by Otterwasser is installed for 100 flats and a school in Linz, Austria for the big utility LINZ AG, as a demo- and research unit. Huber Technology, a large company for wastewater treatment units for the international market, has installed a similar system in its new office building for 200 employees. GTZ (the German Technical Co-operation) has also equipped its new office building with urine diverting toilets. The urine-diverting system used in Lambertsmühle is low-cost and low maintenance, and thus feasible for smaller villages and single houses in the CEE-countries. It is an ideal compromise where people do not accept dry systems but that has many of the advantages. The disadvantage is the filtrate from the pre-composting chambers that has to be treated in addition.

Box 4.5: The vacuum-biogas concept in practice - the case of Flintenbreite

The residential area of Flintenbreite in the city of Lübeck was constructed in the year 2000 for a final population of 250 people. The city planners wanted an ecological system, and the alternative was composting toilets, which were expected not to be accepted by the houseowners.

Therefore, a system with vacuum system and biogas production for blackwater was developed as a pilot project. The system was planned and designed by the company Otterwasser for a local construction company that developed the area in co-operation with the Lübeck city council. The private company is responsible for the operation of all the technical systems, including heat and power generation and distribution.

In Flintenbreite, a vacuum system with extremely low flush vacuum toilets (0.7 litres/flush) (Figure 4.13) and vacuum sewers (40 to 50 mm diameter) has been installed to collect the blackwater. An evacuation pump station and pneumatic control of the valves are needed for the blackwater system, which can lift the water up to 4.5 meters.

The collected blackwater is then mixed with grinded organic household waste, sanitised and treated in a digester located in the building. After storage, the digested anaerobic sludge is used in agriculture. The produced biogas is used in the building for combined heat and power generation in combination with natural gas. Greywater is treated in constructed wetlands (see Figure 4.13).

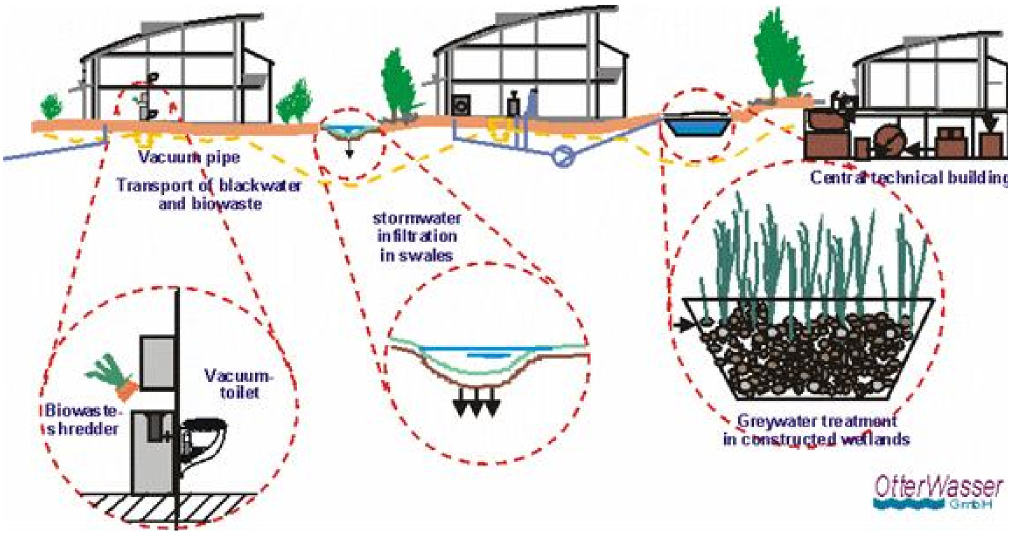


Figure 4.13. The different water flows and treatment systems at Flintenbreite, Lübeck.

Since the installation was a pilot project, the technical details have been improved during the years since the system was first built. The users are now quite content with the system except one family where several severe problems with the toilets occurred. Operational experiences have shown that the system is technically complex and in need of regular maintenance. Scaling occurs in the vacuum pipes and acid should be applied around every 5 years (depending on water hardness). It is also important to explain the function of the system to the users to avoid stopping of the vacuum pipes. The vacuum technology was further developed and supplied by Roediger Vakuum und Haustechnik, Hanau, Germany.

Box 4.6: The blackwater loop concept in practice- the case of Zeche Westfalen

The first commercial installation of a blackwater loop system is under construction in a huge multifunctional building (Zeche Westfalen) in Ahlen, Germany. Conservation of water, nutrients and energy was one reason for the choice of sanitation system, which was made in co-operation with the city planners. The system is designed for 200 users per day.

In the system, toilet wastewater is not wasted but treated for reuse as toilet flushwater and produces thoroughly treated liquid fertiliser in the concentrations of urine. The treatment consists of a membrane bioreactor (MBR) and ozonisation including nitrification, which assures high quality of the water (see Figure 4.14). Faecal matter is co-treated with bio waste in an anaerobic digester. Greywater is treated separately in a membrane bioreactor before infiltration into the local aquifer.

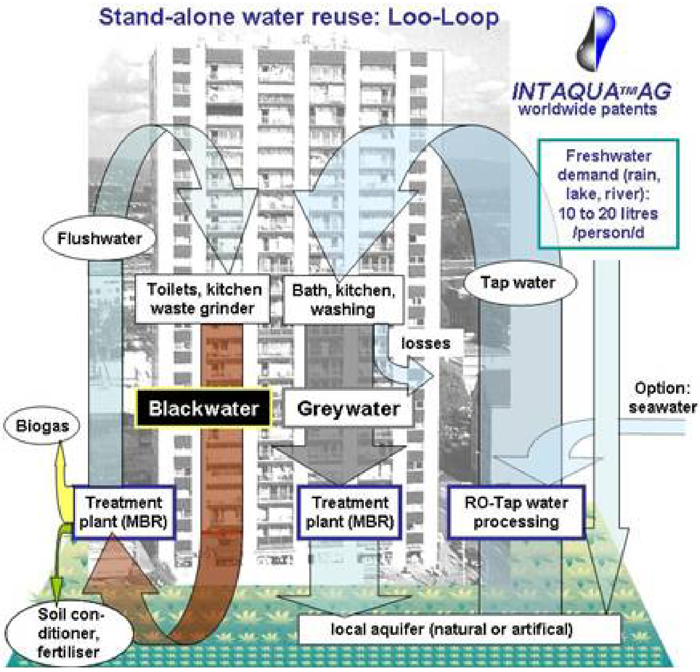


Figure 4.14. A system sketch of the blackwater loop.

The blackwater loop is feasible in new constructions, where there is no wastewater system in place. Conventional toilets can be used. The system does work, but it is too early to draw any conclusions. The system is technically complex, which has to be taken into consideration when organising and financing operation and maintenance. It can be very economic in new construction above 250 people and hotels of such a size. Hospitals could implement the blackwater loop to sanitize the toilet wastewater and to treat the pharmaceutical residues. Emission to public sewers is a hygienic risk that should be avoided. In areas with sufficient water supplies there would only be greywater treatment and reuse / infiltration but not tapwater recycling.

Box 4.7: The urine-diverting and brownwater treatment concept in practice - the case of Lambertsmühle

In the year 2000, the ancient water mill Lambertsmühle was reconstructed as a museum. At the same time, the wastewater system was reconstructed. Previously, all the wastewater was collected in a collecting tank. Now, with the new source-separated system, the museum displays the concept "from bread to grain" in addition to "from grain to bread".

The new wastewater system is based on urine-diversion toilets, where faeces and toilet paper are flushed with a small amount of water. Waterless urinals are also installed to minimise water usage and dilution of urine. The urine is collected in a storage tank prior to use in agriculture (Figure 4.15). The brownwater is filtered and pre-composted in a two chamber separation unit. After pre-composting, the brownwater thick matter is mixed with organic kitchen garbage and grass cuttings and composted in a garden composter. The filtrate of the separation unit is co-treated with the greywater in a reed-bed filter.

Figure 4.15. Urine tank and constructed wetland for treatment of greywater and leachate from the separation unit in Lambertsmühle.

An investigation programme taking place 2001–2003 evaluated the wastewater system at Lambertsmühle. The results are generally very positive and show a lot of benefits of source-separating systems. Urine can act as a very good fertilizer and after storage in acid conditions, pathogens are destroyed and urine is hygienically harmless. The solid removal in the separation unit is very efficient, but the composting effect is negligible. Experiences also show that not every separation toilet can be recommended, especially for children. Persistent organic pollutants present in urine need to be further investigated. It is planned to improve composting by adding worms in the warmer season while the chambers are warmed up to above 20 °C with a very simple solar system (black pipe with solar pump).

Read more

www.otterwasser.de
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www.lambertsmuehle-burscheid.de
www.ecosan.org
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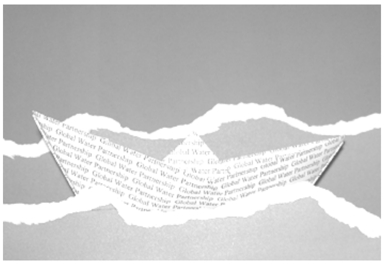

Chapter 5

Legislation on Sustainable Sanitation in EU

Jonas Christensen

INTRODUCTION

EU Environmental law is based on the global principle of sustainable development. This principle is emphasised in the Rome treaty, and elaborated in the sixth environmental action programme and further on in the EU sustainable development strategy. Sustainable development includes classic environmental questions, such as pollution and health protection issues as well as resource management issues. Health protection, protection against environmental degradation and recyling are also the three primary functions of sanitation systems (see Chapter 3).

While it is easy to find EU secondary legislation aiming at bringing down pollution, such as eutrophication and health risks, the legislation concerning use of natural resources, in the field of sewage sludge and other sewage fractions, is more contradictory and difficult to interpret. Community law does not restrain the member states from implementing legislation that allows or obligates sewage systems that may (shall) separate urine and/or faeces. On the other hand, the EU legislation may make it difficult to find use for those fractions. Whether source-separated urine or faeces are included in the term "sewage sludge" is still under discussion.

This chapter gives a brief overview of the EU environmental legislation and EU legislation regarding sustainable sanitation. By necessity, the description is simplified and in some cases generalized.

SOURCES OF EU LAW

The European Community is built up by its own legal system. When member states once signed their treaty of Accession or (from the very start) the Rome Treaty, they transferred parts of the legislative powers from the national parliament to EU institutions. The member states have also submitted to EU legislation, for example to implement directives in a proper way. This is expressed in Article 10 of the Treaty: "*Member States shall take all appropriate measures, whether general or particular, to ensure fulfilment of the obligations arising out of this Treaty or resulting from action taken by the institutions of the Community. They shall facilitate the achievement of the Community's tasks*."

It is possible to establish the following four major sources of Community law:

1) Acts of member states (the so called primary law).
2) Community acts (the so called secondary law).
3) The general principles of Community law.
4) International conventions between the Community and third parties.

The primary law consists of the Rome treaty and other constitutive treaties, and the secondary law consists of Regulations, Directives, Decisions, Recommendations and Opinions. The general principles of Community Law are principles adopted by the European Court. The most important acts of the secondary law may be described as follows:

a) *Regulation:*

- the strongest form of legislation,
- no possibilities for the member states to change a regulation through national implementation,
- directly applicable to the member states and their citizens,
- will be part of the national legislation without any implementation (procedure) by the member state.

b) *Directive:*

- general determination of the Community objectives to be adapted by the member states,
- has to be implemented into the national legislation due to the national legal actions of the Member State.

c) *Decision:*

- rather a state management activity than legislation,
- valid and binding only for the addressee, therefore no general enforcement or application.

The Community legislation has a priority considering national legislation elaborated either before or after the Community legislation. Due to the direct effect of the Community regulations and some of the directives, the legislation may often be referred to direct in the national courts of the member states. According to the principle of supremacy the rights determined by the Community legislation have to be enforced even if it is in contradiction with the national legislation. Although the member states have accepted this priority, due to special constitutional requirements of these states this priority issue is much debated from time to time.

SUSTAINABLE DEVELOPMENT IN EU LAW

From a global perspective, the development of the environmental law may be divided into three "generations". The first generation of environmental legislation focused only on health protection. The main aim was to prevent diseases to be spread. During the second generation, legislation aiming at protect the environment it self evolved. The third and (so far) last generation of environmental legislation aims as well to save and reuse natural resources. The three "generations" also reflect the three primary functions of sanitation systems[34].

[34] The three primary functions of santiation systems are explained and discussed in chapter 3.

Today, the EU environmental legislation is based on the international accepted, global goal on Sustainable Development[35], a goal that contains all three of the above mentioned generations. Emphasis on Sustainable Development is already laid out in the Articles 2 and 174 in the Rome treaty, and the integration principle (Article 6) implies that environmental concerns (based on the principle of sustainable development, shall be taken within all kinds of decisions.

Article 174 gives the frames for how and when the Community shall introduce common environmental legislation, but it is also a tool for the interpretation of existing Community legislation (EU regulations and EU directives, and national law implementing EU law). In the first part of Article 174 the objectives for the community environmental policy is laid down. This should be read together with Article 2. In the second part of Article 174 important environmental principles for the EC is laid down.

Box 5.1: The Rome Treaty

Article 2

"The Community shall have as its task, by establishing a common market and an economic and monetary union and by implementing common policies or activities referred to in Articles 3 and 4, to promote throughout the Community a harmonious, *balanced and sustainable development* of economic activities a high level of employment and of social protection, equality between men and women, *sustainable and non-inflationary growth*, a high degree of competitiveness and convergence of economic performance, a high level of protection and improvement of the quality of the environment, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States"

Article 6

"Environmental protection requirements must be integrated into the definition and implementation of the Community policies and activities referred to in Article 3, in particular with a view to promoting sustainable development.

Article 174

1. Community policy on the environment shall contribute to pursuit of the following objectives:
   - preserving, protecting and improving the quality of the environment, protecting human health,
   - prudent and rational utilisation of natural resources,
   - promoting measures at international level to deal with regional or worldwide environmental problems.
2. Community policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. In this context, harmonisation measures answering environmental protection requirements shall include, where appropriate, a safeguard clause allowing Member States to take provisional measures, for non-economic environmental reasons, subject to a Community inspection procedure.
3. In preparing its policy on the environment, the Community shall take account of:
   - available scientific and technical data,
   - environmental conditions in the various regions of the Community.

The principles mentioned in the second part of Article 174 are:

- *The Principle of a high level of protection* is one of the most important substantive principles of European environmental policy. It states that EC policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the EC.

[35] The term Sustainable Development was elaborated in Our Common Future, 1987 (the so called Brundtland report). See also chapter 3 for a definition of sustainable development.

- *The Precautionary Principle* means that if there is a strong suspicion that an activity may cause harm in the environment, it is better to act before it is too late rather than wait until scientific evidences on its harmlessness is available.
- *The Principle of Preventive Actions* allows action to be taken to protect the environment or human health at an early stage instead of waiting.
- *The Polluter Pays Principle* means that it is those who cause the pollution that shall pay for the remediation measures.
- *The Principle that environmental damage should, as a priority, be rectified at the source* means that damage to the environment should preferably not be prevented by using end-of-pipe technology.
- *The Safeguard clause* provides that a directive or regulation may include a safeguard clause which allows member states to take measures to protect the environment in case of urgency.

Since 1973, the EU (EC) has produced six environmental action programmes, which contain the priority plans for the coming years. The sixth Environment Action Programme[36] (for the period 2001–2010) provides the environmental component of the Community's strategy for Sustainable Development, placing the EU environmental plans in a broad perspective, considering economic and social conditions. The action programme is a binding document. In the program, the European Environment Agency's is quoted, stating that *sewage and water treatment* has improved the health of many of our lakes and rivers.

The environmental programme focuses, among two other issues, on the priority issues, (iii) *environment and health*; and (iv) *ensuring the sustainable management of natural resources and wastes.* Both are of interest for sustainable sanitation. The Community's approach to waste management policy is based on the guiding principle of the waste hierarchy which gives preference first to waste prevention, then to waste recovery (which includes reuse, recycling and energy recovery, with preference being given to material recovery), and lastly to waste disposal (which includes incineration without energy recovery and land filling). Another objective is to achieve a situation where the wastes that are still genereted are non-hazardous or at least present only very low risks to the environment and our health.

In the renewed EU sustainable development strategy[37], Conservation and management of natural resources is one of seven key challenges, where the overall objective is to improve management and avoid overexploitation of natural resources. The resource efficiency should be improved to reduce the overall use of non-renewable natural resources and the related environmental impacts of raw materials use, thereby using renewable natural resources at a rate that does not exceed their regeneration capacity.

SUSTAINABLE SANITATION IN EU ENVIRONMENTAL LAW

In the EU legislation, at least the following legal acts are of interest when analysing the possibilities for member states to introduce or keep sustainable sanitation solutions, that is legislation that influence the demands for reduction of pollution and sanitary risks and/or promotes or is an obstacle for the reuse of natural resources (here sewage sludge, human urine, human faeces, etc.)[38]:

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[36] *"Our Future Our Choice"* adopted by the European Parliament and the European Commission
[37] Council of the European Union 26 June 2006, 10917/06
[38] Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (The IPPC directive) focuses only on large enterprises and is not of relevance in this study.

- Directive 2000/60/EC of the European Parliament and of the Council Establishing a framework for community action in the field of water policy (The water framework directive).
- Directive 91/271/EEC concerning urban wastewater treatment (The urban waste water directive).
- Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage is used in agriculture (The waste water in agriculture directive).
- Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (The nitrate directive).
- Directive 1999/31/EC of 26 April 1999 on the landfill of waste (The landfill directive).
- Regulation (EC) No 1980/2000 of the European Parliament and of the Council of 17 July 2000 on a revised Community eco-label award scheme (Eco-label regulation.)
- COMMISSION DECISION of 28 August 2001 establishing ecological criteria for the award of the Community-label to soil improvers and growing media.

The water framework directive

The water framework directive is an integrated Community policy on water, and it aims at maintaining and improving the aquatic environment in the Community. The prevention from further deterioration is crucial. The directive defines pollutants as any substance liable to cause pollution, for example substances which contribute to eutrophication (in particular, nitrates and phosphates), and substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.).

This purpose is primarily concerned with the *quality* of the waters. Control of quantity is an ancillary element in securing good water quality and therefore measures on *quantity*, serving the objective of ensuring good quality, should also be established. With *regard to pollution* prevention and control, Community water policy should be based on a *combined approach* using control of pollution at the source through the setting of emission limit values and of environmental quality standards. For water *quantity*, overall principles should be laid down for control on abstraction and impoundment in order to ensure the environmental sustainability of the affected water systems.

Each Member State shall ensure the establishment of a programme of measures for each River Basin District in order to achieve the objectives of the directive. Environmental Quality Standards shall be decided for every river basin, and they will then set the limit for further pollution. The water framework directive is a minima standard directive and the Member States are free to keep or introduce stricter national legislation.

Since the directive partly is built up on environmental quality standards, the implementation of it in the member states will have legal effects on all kinds of polluting sources, independent on if they are large scale or small, for example small sewage systems. Member states are also free to implement stricter legislation. Each action programme of measures shall include the "basic" measures, such as prohibition of direct discharges of pollutants into groundwater. No exception is done for small scale pollution. Member States should have implemented this directive at the latest 22 December 2003.

The urban wastewater treatment directive

The EU Directive 91/271/EEC on urban wastewater treatment was taken into force in 1991. The aim of this legislation is the *protection of the environment* from *the harmful effects of the* *treated wastewaters*, *to protect the surface and ground waters by achieving a "good status" for them*. For this purpose all member states have to ensure the appropriate wastewater treatment.

However, the Directive deals with agglomerations with more than 2000 pee. only. The exception is Article 7, which deals with small agglomerations if they have a collecting system. The directive conclude that *on-site treatment systems* or *other alternative solution* can be used instead of collecting systems if the establishment of collecting systems is not reasonable, either because of the high expenses or because it would not create environmental benefits[39]. This is probably the case for most of the small settlements with less than 2000 p.e.

The directive suggests that the *treated wastewater*[40], and the *sludge* originating from wastewater treatment[41] *has to be reused* wherever it is possible, in a way so that harm to the environment is minimized. Therefore this Directive can generally aid the establishment of sustainable sanitation in the EU countries. The Directive does not deal with sensitive rivers and lakes in case of small settlements. This issue falls under the framework directive on water and has in some extent o be managed by each member state. The directive emphasises the importance in reusing sewage sludge and wastewater, which is also in line with the waste hierarchy.

The urban waste water directive is a minima standard directive and is not an obstacle for member states to introduce neither stricter rules for large scale plants, nor rules at all for small scale plants or on situ treatment for wastewater. The EU emphasis on sustainable development, including house keeping with natural resources in form of recovery/reuse may open up for national legislation on reuse of wastewater nutrients.

The landfill directive

The landfill directive is based on the waste hierarchy, whereas the prevention, recycling and recovery of waste should be encouraged as should the use of recovered materials and energy so as to safeguard natural resources and obviate wasteful use of land. Member States shall set up a national "step-by-step-strategy" for the implementation of the reduction of biodegradable waste[42] going to landfills.

Not later than 2016, biodegradable municipal waste going to landfills must be reduced to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1995[43]. In the preamble, emphasis is laid on that member states should take the measures necessary to reduce the landfill of biodegradable waste, by encouraging the separate collection of biodegradable waste, sorting in general, recovery and recycling. Thus, sewage sludge should preferable not be landfilled.

The wastewater in agriculture directive

The aim of this Directive is to regulate the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, while encouraging its correct use. The core is a prohibition of the use of sludge where the concentration of certain heavy

[39] Article 3 point 1
[40] Article 12 point 1
[41] Article 14 point 1
[42] . Biodegradable waste" means any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard.
[43] Or the latest year before 1995 for which standardized Eurostat data is available.

metals exceeds the limit values laid down in the directive. This is a minimal standard directive and the member states may implement stricter legislation than the directive. The directive is also applicable on sludge from small treatment plats or in situ treatment. It is uncertain if the term sludge includes pure fractions of human urine or faeces as well (which is a crucial issue for source-separating systems).

Member States shall prohibit the use of sludge or the supply of sludge for use on: (a) grassland or forage crops if the grassland is to be grazed or the forage crops to be harvested before a certain period has elapsed (set out by the member states), (b) soil in which fruit and vegetable crops are growing, with the exception of fruit trees; (c) ground intended for the cultivation of fruit and vegetable crops which are normally in direct contact with the soil and normally eaten raw, for a period of 10 months preceding the harvest of the crops and during the harvest itself. The Directive also requires that sludge should be used in such a way that account is taken of the nutrient requirements of plants and that the quality of the soil and of the surface and groundwater is not impaired.

On one hand, the directive shall encourage the use of sludge, but it is on the other hand written in such a way that it in practice works as an strong obstacle. Member states are, for example, obliged to prohibit the use of sludge on some kinds of cultivations.

The Nitrate directive

One of the main causes of pollution by nitrates from agricultural sources is the use of fertilizers containing nitrates on farmlands. The directive also applies on sewage sludge used as fertilizer. Inside "vulnerable zones "(decided and pointed out by the member states) member states must establish action programmes consisting mandatory measures, and outside these zones some general obligations apply and member states must establish a code of good agricultural practice. The purpose of this directive is the protection of surface- and ground waters from nitrate pollution, but may at the same time be an obstacle when it comes to possibilities to reuse sewage sludge on farmlands.

The Eco-label regulation

The Community eco-label may be awarded to products available in the Community which comply with the essential environmental requirements and the eco-label criteria[44]. The EU Commission has decided that in order to qualify for the eco-label, a soil improver or growing media shall not contain sewage sludge[45]. The eco-label regulation applies only to them who wants to join the EU eco-label system (to sell eco-label products), and because of its status as a regulation the member states are not obliged to set other rules. The eco-label regulation and the commission decision is an important obstacle for the legal possibility to reuse sewage sludge on eco-label farmland. But whether human urine and faeces shall be classified as sludge or not is under discussion. If they are seen as categories on their own, at least these legal acts will be no obstacle for the possibilities to reuse these fractions for cultivation of eco-labelled crops.

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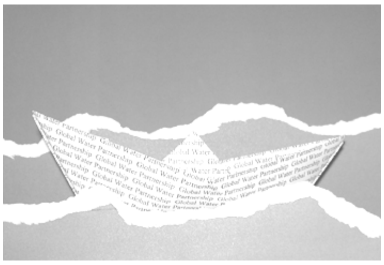
[44] Set out in Article 1

[45] Annex, Ecological criteria,a and b.



Chapter 6

Conclusions and Recommendations

This book aims at enlightening, guiding, and inspiring policy makers, administrators, practitioners and all stakeholders on how Sustainable Sanitation can be used in small settlements. The book is a result of a joint effort by the partners of Global Water Partnership in Central and Eastern Europe (GWP CEE), representing eleven countries. It provides a first answer to a demand to find solutions to supply small settlements with appropriate sanitation services. "*This book recognizes that sanitation is the foundation of human health, dignity and development. And it calls attention to a serious challenge – how to radically increase access to basic sanitation in ways that reflect the principles of economic efficiency, social equity and environmental sustainability – the 3 E's – on which the Integrated Water Resources Management approach is built*" (from the Foreword by Roberto Lenton). This GWP CEE initiative on sanitation by the stakeholders from different sectors is an entry point to manage the common European water resources in an integrated and sustainable way.

Conclusions are summarized from the five chapters of the book.

Chapter 1

- Access to safe, comfortable and affordable sanitation is a basic human demand. At the same time the handling human excreta and wastewater, pose a serious risk to human health, to the environment as well as it degrades our common natural recourse base upon which the human society is built. It is a responsibility and a challenge of our societies to enable people with functional sanitation and to develop handling systems of excreta and polluted water in a safe and sustainable way.

Chapter 2

- *The European countries of the Central and Eastern Europe have experienced unique political, economic, and social changes which date back to the era of the Soviet Union force in the region. Today's overall level of water supply is quite high while at the same time the level of municipal wastewater treatment in majority of the countries is poor.*

- *Functional sewer and treatment systems are mainly found in big cities and towns. In spite of this fact investments for upgrading systems into conventional sanitation techniques are required and need tremendous costs and are not in harmony with available economic resources.*

- *The EU Urban Wastewater Directive stipulates that sewer and treatment system should be built before 2015 for agglomerations larger than 2000 person equivalents (p.e.) For these and larger settlements funds and grants for the construction of sewer systems and treatment plants are available from EU. For the people living in small and medium size settlements subsidies for investments are out of scope unless "artificial"agglomerations are created by grouping them to meet the basic criterion for receiving subsidies spent ineffectively but coming from taxes of EU citizens.*

- About 25 million people in CEE countries (20% of population) live in small and medium size settlements (less than 2000 p.e). In general these settlements have insufficient or no wastewater treatment systems and low capacity for implement and maintain any sophisticated system. Cheap, simple and robust systems such as water less systems based on urine diversion, onsite or cluster treatment system based on natural soil filter system, irrigation and other natural treatment concepts are realistic solutions that meet modern targets of the EU Water Framework Directive and Sustainable Development.

Chapter 3

- The three primary functions of sanitation and wastewater treatment are protection of public health, recycling of nutrients and protection against environmental degradation. For the system to be sustainable, these primary objectives have to be balanced against technical, socio-cultural (among them the private goals) and economic considerations.

- A clear definition of the system boundaries is crucial, since it is within the system that targets are to be achieved. It is important to be aware of all parts of the system and to have in mind that the output from the system (e.g., treated wastewater and rest products such as faeces, urine or sludge) depends on the input. A "system approach" on sanitation thus means that precautionary actions (source control) should always be considered, e.g., separation of toilet waste and grey water or reduction of phosphorous in household detergents.

- When choosing a sanitation system, the focus should be on the function of the system, i.e., performance regarding primary functions as well as practical considerations. Technology is a means of achieving these goals and not a goal in itself. It is important that user and institutional capacity (software) is compatible with the technical system (hardware).

- Technology used in different situations will differ, since it is chosen from local conditions, the primary targets and practical considerations. Both conventional and new "ecological" technologies may be relevant and should be considered and evaluated in a planning situation.

- Open Wastewater Planning is a useful planning method for sanitation projects. It is a simple and flexible method that focuses on the desired performance of the sanitation system, rather than on a specific technology and can be used both in comprehensive planning and when planning a local sanitation system.

Chapter 4

- The constructed wetland concept (i.e. filtering pre-treated wastewater water in a saturated soil filter media planted with reed and other halophytic plants) has been found appropriate for biological treatment for small settlements in many countries. The example from

Slovenia proves that the technique is simple, relatively cheap and demands very little maintenance.

- Wastewater can be used for irrigation of meadow forests. This old and natural way to handle wastewater gives the double value, i.e. to clean and evaporate polluted water and to produce valuable crops. Examples from Hungary show a potential to develop forest irrigation for safe and efficient reuse of wastewater in many CEE countries.

- Urine-diverting systems is a simple and cheap method to improve sanitation for many people. By diversion and use of the human urine for crop production instead of mixing it in large amounts of water, nutrients can be reused and no cost has to be spent on nitrogen and phosphorous removal in wastewater treatment. Examples from Ukraine show that dry urine diverting toilets are appropriate in rural areas. Experiences from installations made for schools have radically improved sanitary conditions and a local market for manufactures and constructors is developing.

- In Sweden more than 90% of the population is connected to centralised sewage systems with biological and chemical treatment. People living in the countryside are served with onsite treatment mainly infiltration and sand filter systems. A strong legislation and large subsidies from government during 1970-80 made this development possible.

- Despite the fact that most sewage is managed in advanced wastewater treatment plants there has been a great interest in research and development of cheap, natural treatment systems. Many old treatment ponds were successfully improved by adding lime or aluminium as coagulants. Vertical soil filters were used as a main treatment concept for single houses. More than 30-40 years of operation of more than 100,000 facilities prove that unsaturated flow in soil media provides an efficient and reliable technique for treatment. Despite the cold and wet climate in Sweden forest irrigation was found to be a relevant concept for small settlements. At present urine diversion and compact soil filter techniques also become competitive.

- Centralised wastewater systems are well developed in Germany. However mainly due to increasing maintenance and operation costs and lack of nutrient recycling, new technologies have been developed. Focus has been on systems with separation of blackwater since they are easily adapted to urban settings. Toilet waste (blackwater) has a high content of pathogens and nutrients, but the produced volume is very small. Greywater (from washing, etc.) has a low content of both pathogens and nutrients, but is produced in large volumes. When not mixing these two fractions, treatment and recycling of nutrients can be more efficient. Experiences show that vacuum based blackwater systems are well accepted by users but the level of technology make them depending on careful installation and operation. Economically blackwater systems are compatible with conventional systems.

Chapter 5

- The environmental issue is ranked very highly on the EU agenda and EU Environmental law is based on the global principle of sustainable development. This principle is emphasised in the Rome treaty, and elaborated in the sixth environmental action programme and further on in the EU sustainable development strategy. Sustainable development includes classic environmental questions, such as pollution, health protection issues and resource management issues.

- The EU environmental policy is based on the Principle of a high level of protection, the Precautionary Principle, the Principle of Preventive Actions, the Polluter Pays Principle, the Principle that environmental damage should as a priority be rectified at source and finally the Safeguard clause. All these must be taken into consideration when implementing new, or restoring existing, sanitation systems.

- While it is easy to find EU secondary legislation aiming at bringing down pollution, such as eutrophication and health risks, the legislation concerning use of natural resources, in the field of sewage sludge and other sewage fractions, is more contradictory and difficult to interpret.

- Pollution to waters (surface water and ground water) is mainly dealt with in the *water framework directive (EU WFD).* This directive has different approaches, one way is the implementation of environmental quality standards and the other way is technical standards and effluent values. When implemented by all member states, the *EU WFD* will have a direct influence on large as well as medium and small pollutant sources.

- The water *EU WFD* is an anti-pollution directive. The importance in reusing sewage sludge and waste water is on one hand underlined, but on the other hand there are no explicit legal demands on how this should be done ore promoted. But it is no legal obstacle for the member states that find it necessary to implement national legislation on the reuse of natural resources. Additionally, the spirit of EU legislation is based on the rule of application of more stringent national environmental legislation if reasonable or needed.

- *The urban wastewater treatment directive* is mainly focused on large systems, and forces the member states to have a high standard of their sewage treatment. The directive focuses on pollution, and the conclusion is that this directive will not be any obstacle for those member states that will use "alternative sewage techniques" at least in these large scale systems. Instead of collecting systems, *on-site treatment systems* or *other alternative solution* can be used if the establishment of collecting systems is not reasonable, either because of the high expenses or because it would not create environmental benefits, which is the case in most of the small settlements with less than 2000 p.e.

- *The landfill directive* is based on the waste hierarchy, meaning that waste in first hand shall bee seen as resources. Member States shall set up a national "step-by –step-strategy" for the implementation of the reduction of biodegradable waste going to landfills. Biodegradable waste includes sewage sludge and other separated waste fractions, such as urine an faeces, shall not be deposed. The possibility to find use for sludge and sewages fractions is not easy.

- When it comes to the possibilities to use sewage sludge on farmland, the *waste water in agriculture directive* forces the member states, because of sanitary risks, to implement prohibitions to spread sludges on farmland used for some kinds of food or feed growing. There are also limits for how much sludge that may be spread because of the load of heavy metals. One unsolved question is the interpretation of the term "sludge". *The Nitrate directive* covers sewage sludge, and may in sensitive areas be an obstacle for reusing sludge on farmlands. Even *the eco-label regulation* is an obstacle for the possibilities to find use for at least sewage sludge.

- The main conclusion is that that community law does not restrain the member states from implementing legislation that allows or demands sewage systems that separate urine and / or faeces. This is also in line with the Treaty based on a sustainable development. On the other hand, the EU legislation may make it difficult to find use for those fractions. There are legal obstacles for the use of sewage sludge, but the question is if pure fractions of urine and faeces shall be included in "sludge". A possible interpretation, based on the fundamental principle on sustainable development, written in the EU Treaty, elaborated within the EU law and environmental action program, is that pure fractions of human urine and faeces are not included in the term "sludge".

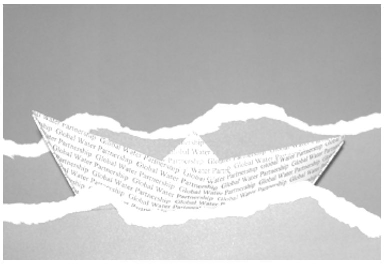
Recommendations

At national level:

- Adapt rules and regulations to EU legislation (if not applied till now) and sustainability principles (described in Chapters 3 and 5)
- Develop a national strategy to change existing sanitation situation towards sustainability principles. Such a strategy should include priorities and guidelines for planning and financing of sanitation (including planning, construction, operation and maintenance of the systems).
- Initiate and promote Research and Development of appropriate planning methods, financial systems, technical solutions for handling excreta, wastewater and sludge.
- Demonstrate and disseminate good examples

At local level

- Start planning process from the local situation with discussions about individual and common targets. Define problems and make priorities.
- Investigate different options from articulated targets (primary functions) and consider practical aspects, e.g. institutional capacity, user awareness, possibilities for financing investments, relevance and robustness of technique, legality and control, operation and maintenance of the system.
- Involve representatives of main stakeholder groups in the planning process e.g. users/owners, landowner, farmer, environmental organisations etc.
- Learn from good examples and start with pilot projects before starting up large-scale projects.



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