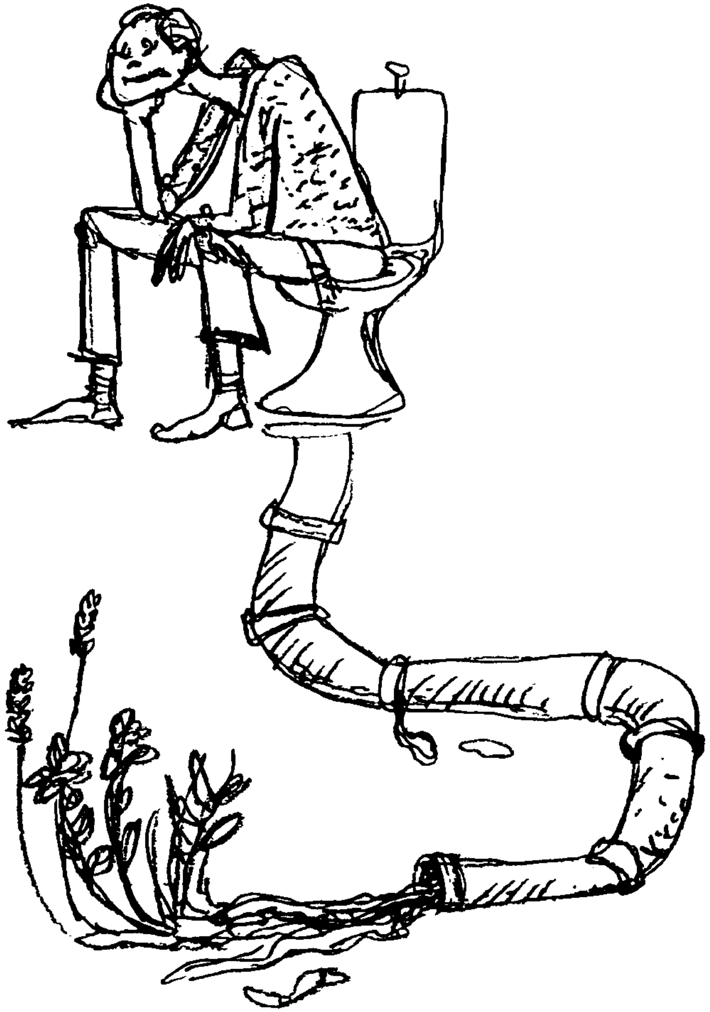
WASTEWATER TREATMENT IN A SMALL VILLAGE
- options for upgrading -



SWEDENVIRO

WRS
Water Revival Systems

SwedEnviro Report no. 1999:1

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Preface

This production has been initiated and financed by Coalition Clean Baltic (CCB) to give support for long-term sustainable solutions for wastewater treatment in the Baltic Sea region. We hope that the planning ideas and the treatment methods presented in this booklet will inspire to use more cost-efficient and recourse saving technologies, for the benefit of the society as well as the Baltic Sea environment.

Gunnar Norén
CCB Executive Secretary

Foreword

In Sweden, many new wastewater treatment systems were built during the period 1970-1980. More than 70,000 km of sewage pipes and many thousand treatment plants were built. Today wastewater from 90% of the population is treated in central treatment plants, most with very similar designs.

Many of these sewage systems and treatment plants now require renovation. This report suggests how the renovation can be planned, and gives a number of examples of treatment options that can be appropriate for a small community in the countryside.

The report is based on work done for the municipality of Flen, Sweden, which wished to replace an old, run-down treatment plant. A similar situation exists in many places today, including Estonia, Latvia, and Lithuania.

It is important for all the countries around the ecologically sensitive Baltic Sea to use wastewater treatment technology that not only protects the environment from water pollution, but also recycle nutrients, like nitrogen and phosphorus, to agriculture. We hope that this report will give inspiration and ideas about how this necessary development of wastewater treatment can be implemented.

Carl Etnier, from the Department of Agricultural Engineering at the Agricultural University of Norway, and Ola Palm, of Palm Enviro and the Swedish Institute of Agricultural Engineering, have provided much expert assistance. Etnier has translated the original Swedish report and some supplementary material into English, Palm has drafted some of the material, and both have helped revise the original report. Diana Chace has helped increase the clarity and improve the language of the final product. The responsibility for the content of the report is entirely mine.

Peter Ridderstolpe
WRS AB
Uppsala, Sweden April 1999

A planning method for upgrading of wastewater treatment plants

Introduction

Many small-scale wastewater treatment plants in Sweden require renovation, due to their age, new standards for wastewater treatment, or an increasing population connected to the plant. Older plants are especially likely not to meet today's requirements for phosphorus and bacterial discharges.

The goals of wastewater treatment have evolved, as understanding of the biology of the receiving waters has increased. A century ago, an important goal was to get rid of unpleasant waste products close to where people were living. Building of collection systems for wastewater, placing outlets away from drinking water sources, and introduction of water closets were some of the means to achieve a better hygienic standard for people in urban areas. The next step was to reduce the water pollution caused by these collection systems. Suspended solids and organic matter were removed from the wastewater through mechanical and biological treatment. In mechanical treatment, suspended solids are removed mainly through gravity, while in biological treatment, organic matter is consumed by bacteria in, for example, a trickling filter or an activated sludge process. These treatment steps led to better light penetration and oxygen conditions in the receiving waters. However, the problem of eutrophication in inland waters remained, due to discharge of phosphorus in the wastewater. Thus, chemical precipitation was introduced in many plants, resulting in low levels of phosphorus in the outgoing water. During the last decade, nitrogen removal systems have been installed in medium- and large-scale treatment plants in coastal areas to improve the situation in the sea.

The above measures could be summarised as health protection and protection of receiving waters. However, today an old goal for wastewater treatment has been reintroduced—recycling nutrients in wastewater back to agriculture, sometimes called creating an "ecocycle" of plant nutrients. While this was an important part of the treatment of human waste in some European cities during the 1800s, it virtually disappeared from the agenda during the 1900s. Phosphorus is an especially important nutrient to recycle, as the phosphorus in chemical fertiliser comes from limited, fossil sources. Nitrogen is also important, since about one kilogram of oil is required for every kilogram of nitrogen fertiliser manufactured. Linking urban areas closer to agriculture, through nutrient recycling, is one step in achieving a sustainable society.

Whether an existing treatment system is to be renovated or a new system built, the planning should ensure that all the goals of treatment be considered, that different options be evaluated, and that costs for construction and maintenance of all the options be compared.

Planning method/process

In the beginning of the planning process, it is important to resolve three issues:

- The boundary of the system must be defined, geographically as well as physically. For example:
  - Which properties are, or should be, included?
  - Should part of the receiving water (e.g., a wetland or a ditch) and/or agricultural land (e.g., for irrigation or use of sludge) be included in the treatment system?
  - Does the system start at the boundary of each connected property, or could/should the plumbing in the houses be included? (Systems involving source separation require changes in the plumbing.)
- Standards for the system must be formulated, considering the receiving water and other local circumstances. For example:
  - What goals have been set for the receiving water in the local water planning document?
  - What demands do other users have on the receiving water, for bathing, drinking water, etc.?
  - What possibilities exist for recirculation of nutrients from the system (i.e., does suitable agricultural land exist, are farmers interested in cooperating, etc.)?

- The actors and the roles do they play must be identified. For example:
  - Municipality (could be as land owner and/or local environmental and planning authorities. The municipality could also be the owner of the system)
  - Property owners (are usually those who use and pay for the system through fees)
  - Farmers (could be contractors who sell or lease land for the system, receiver/user of nutrient resources from the system)
  - Contractors (operating parts or the whole system)

Answering these questions gives a framework for the planning process. The next step is to investigate and describe different system options. Each option should be investigated and described according to the framework, and a report should be made as to how well the standards will be met. It is important to describe the options not only in economic terms but also in terms of performance and the other goals.

The final step is to compare the alternatives and reach a decision. This step will also involve, implicitly or explicitly, a weighting of the relative importance of the various goals.

This booklet illustrates the planning process described above, through a case study that has been carried out in the small community of Flen, Sweden. A version of this report was presented for the municipality. In the Afterword, you will find the municipality's decision.

What requirements should be set?

Wastewater treatment has three primary functions:

- to prevent spreading of diseases
- to reduce the nutrients and other pollutants released to recipient waters, and
- to recycle nutrient resources into agriculture or other production.

In Sweden, the law does not say which technology must be used for treatment or exactly how much the treatment must improve water quality. The Environment Code does require, however, that the best treatment technology that is economically reasonable be used. Furthermore, the Code states that sanitary nuisances are not acceptable. In Vadsbro, the municipality's Environment Protection and Public Health Committee has oversight over the treatment facilities. It is therefore this organ's responsibility to decide what economic costs are reasonable, what water quality gives satisfactory protection against diseases and pollution of surface water, and to ensure appropriate management of the nutrients and other natural resources.

Disease protection

Despite modern wastewater treatment's origins in public health, there are few formal guidelines for public health parameters.

In recent years, however, these questions have received more attention. The Swedish Institute for Infectious Disease Control, the Swedish Environmental Protection Agency, and the National Board of Health and Welfare have recently presented a report on pathogens in the wastewater system. The report warns that the good hygienic standard in Sweden can rapidly degrade, if disease control is not carefully considered when planning wastewater systems. Risks are increasing because people travel internationally more often, which means that microorganisms new to Sweden are being spread in our wastewater systems. In this context, the report shows how poorly thought-out methods for recycling wastewater resources can lead to new ways for pathogens to spread diseases.

Epidemiologists also point out the risks in today's method of treating wastewater. They warn that the present treatment plants have too low levels of pathogen removal, especially when they discharge into placid waters, where the natural rate of mixing is low.

A reasonable requirement for treatment where the public and/or terrestrial animal lives are exposed to the wastewater is that the water must meet hygienic standards for bathing water. If the levels of faecal microorganisms in the wastewater do not meet bathing water quality, the area should be provided with a protective barrier, e.g. thick vegetation or a fence, and warning signs. In Vadsbro, it is unclear whether the present wastewater treatment system meets these requirements.

Recipient protection

There are two generally accepted principles of environmental protection:

1) State-of-the-art technology (Best Available Technology, BAT) is to be used to prevent emission of pollutants
2) The polluter pays the expense of purifying emissions.

These principles are manifested in the recent Swedish Environmental Code and have been in force since 1969 in the former Environmental Protection Act. Furthermore, in Sweden there are no general requirements to fulfil when discharging wastewater. Instead there are a system of individual judgements and permissions, although many of them are similar since conditions in many cases are similar. Thus, Sweden has developed well-functioning routines for judging recipient protection and formulating treatment requirements. These requirements are normally in the form of percentage reduction in the concentration of nutrients (e.g. nitrogen, phosphorus) from the influent to the effluent, together with maximum concentrations.

Generally speaking, BAT for wastewater today has at least the following requirements: phosphorus reduction >90%, BOD reduction >95%, and in coastal areas, nitrogen reduction >50%.

THE FUNCTIONS OF WASTE-WATER TREATMENT

Best Available Technology (BAT) for the function of:

1. HYGIENE

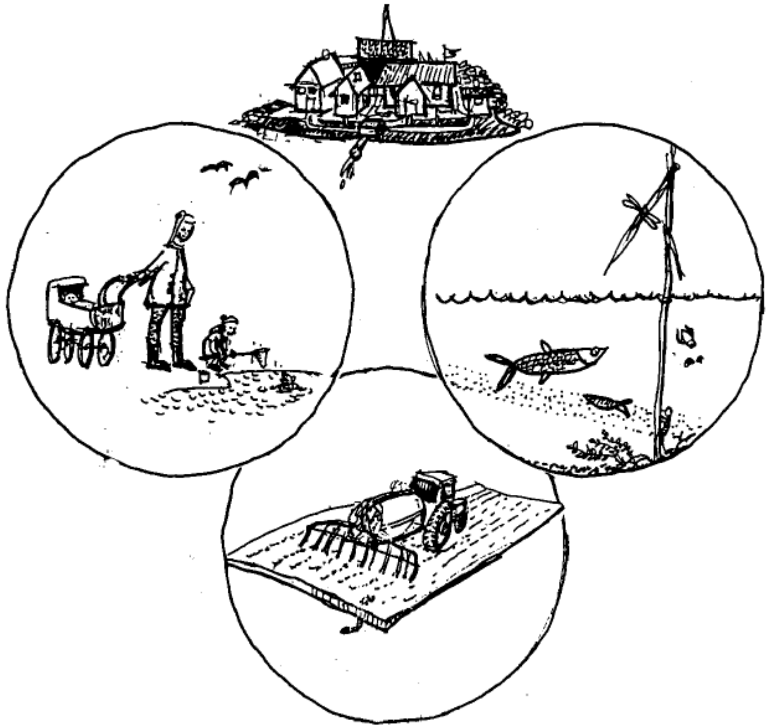
- Avoid sanitary nuisances, e.g. bad odour
- Infectious disease control, i.e. the effluent is either bathing water quality or excluded from direct exposure to humans until it has achieved bathing water quality

2. RECIPIENT

- Phosphorus: reduced >90% (general requirement). In Vadsbro at most 0.1 kg/pers annual discharge and <0,1 mg/l.
- Nitrogen: reduced >50% (general requirement). In Vadsbro at most 2.5 kg/pers annual discharge. Discharged in the form of nitrate.
- BOD: reduced >95%.

3. RECYCLING OF NUTRIENTS AND/OR ORGANIC MATTER

- Phosphorus: >75% recycled
- Other resources valuable for agriculture



There is good reason to state treatment requirements in the form of the highest permissible annual discharge of each nutrient per person served by the system. With this type of requirement, even measures undertaken at the source, like reducing the phosphorus used in laundry powder or installing urine-separating toilets, can be officially acknowledged as improving the wastewater treatment. In addition, requirements based on total discharge mean that technologies which reduce water consumption (and thereby produce a more concentrated wastewater) do not make it more difficult to meet effluent standards. For the same reason, dilution of the wastewater does not help meet treatment requirements. Finally, the total discharge is a more accurate measurement of what affects the recipient as a whole, since differences in effluent concentrations have at most a very local effect.

Formulation of treatment requirements ought to distinguish between regional and local recipient protection. A wastewater discharge may not be harmful to a regional recipient, e.g., a large lake, a bay, or the sea, but nonetheless harm the local recipient, e.g. a stream or river. In Vadsbro, the local recipient is a small drainage ditch, which runs into Lake Vadsbrosjön. Because the rate of water flow through Lake Vadsbrosjön is low during the summer, and the lake can be nitrogen limited or phosphorus limited at different times, increased amounts of phosphorus or nitrogen into the river can cause noticeable eutrophication in the lake. Furthermore, the hygienic standard of the water in the drainage ditch (the local receiving water) is probably poor and, during summer, problems may occur in a nearby bathing beach on Lake Vadsbrosjön. Thus, when upgrading the treatment plant in Vadsbro, both the eutrophication situation and the hygienic standard have to be improved.

Nitrogen in the form of ammonium is a powerful consumer of oxygen in the waters. Therefore it is advantageous if the ammonium is nitrified before it is discharged into the receiving body of water. If dilution in the receiving water is poor, even low phosphorus levels can be damaging. In water bodies with low water flux, phosphorus discharges over 0.1 mg/l easily lead to eutrophication.

Recycling

Wastewater contains all the nutrients from the food we eat. Agriculture can only be sustainable if these elements are returned to the fields. Of the twenty or so nutrients necessary for plant growth, phosphorus can be considered the most valuable. It is often a growth-limiting nutrient, and the fossil reserves of phosphorus are too small to permit long-term exploitation at today's level. Nitrogen can often also be growth-limiting, and thus is valuable to agriculture. (There is no practical limit to the atmospheric supply of nitrogen, but the energy costs for fixing nitrogen for artificial fertilizer are very high.)

Nutrient recycling has not been a design requirement for European wastewater treatment this century. Thus, nutrient recycling systems are poorly developed. As nutrient recycling is once again accorded importance by society, phosphorus recycling to agriculture is today often pointed out as a goal for wastewater treatment. A possible level to reach by BAT today or in the near future is 75% phosphorus recycling.

In Sweden wastewater accounts for approximately one third of the heat loss from homes. Another type of recycling possible from wastewater, then, is reclaiming this heat, using heat pump technology. Discussion of that is, however, outside the scope of this paper.

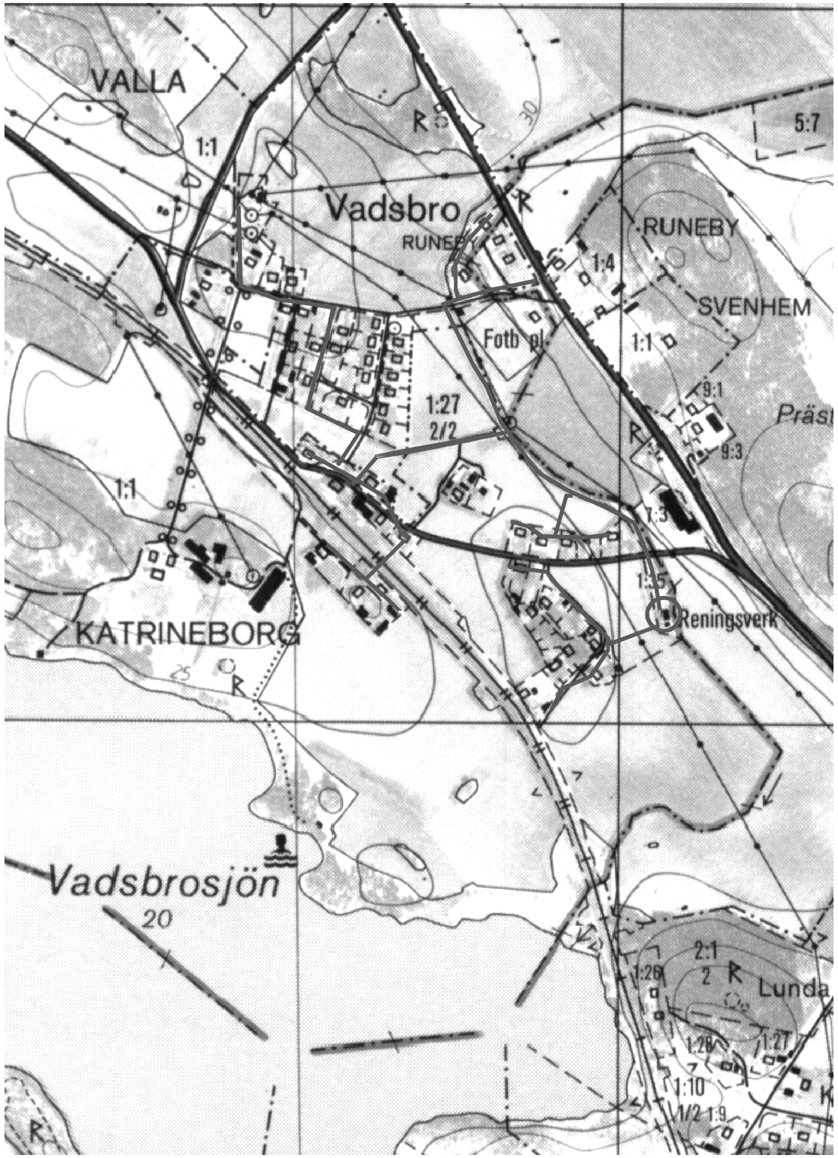
Adaptations to the local situation

Vadsbro is a little community in the countryside. A sewer system connects the village's 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 little, excavated river/ditch that drains both the village and the forest and farms upstream. The treatment plant is surrounded by flat farmland and the owner of the land west of the treatment plant is willing to allow it to be used as part of the wastewater treatment.

A map over Vadsbro before upgrading

The treatment plant (Reningsverk in Swedish) is located along a small stream, which also is the receiving water. The stream finally ends in lake Vadsbro (Vadsbrosjön in Swedish). Close to the outlet in the lake is a beautiful place situated.

Agricultural land is light gray and forest is dark gray. The sewage system is marked in the map



Economics

The present wastewater treatment plant in Vadsbro works poorly and needs to be upgraded. It could either be replaced with a new plant at the same location, or by decentralised treatment facilities located close to the houses served. Centralised treatment requires a larger sewer system. However, this already exists in Vadsbro and works quite well, so no further investment is needed in sewers if the centralised alternative is chosen. The principal economic question, therefore, is the cost of building and running either a new centralised facility or a number of decentralised systems. Different treatment systems have widely varying operating costs, so both construction costs and operating costs need to be considered in any comparison.

Building on-site sewage treatment with infiltration costs today around 4,000 USD per household. For a new, centralised treatment plant to be economically tenable, it must then cost no more to construct than this on-site treatment. If the treatment plant will serve 40 - 45 households, then, it should not cost more than 160,000 – 180,000 USD. The operational costs for a centralised treatment plant are generally higher than for infiltration on site, but this is permissible if they are countered by sufficiently high recycling of nutrients, as infiltration leads to little or no nutrient recycling.

Management of finite resources is also part of the economics. Simple, natural materials ought to be used in building the treatment plant, and the treatment process ought to be solar powered, as much as possible. Energy use (oil and electricity) greater than 300 - 400 kWh per person annually is regarded as a very high figure and needs attention.

Reliability

Wastewater treatment should satisfy ordinary persons' need for comfort and hygiene. Reliability is also important. Taking a chance on less tested technologies is inappropriate unless there are possibilities to achieve exceptional and obvious advantages with regard to hygiene, recipient protection, resource management, and/or economics.

Local adaptations

Incorporating nutrient recycling, or using a natural ecosystem for wastewater treatment, requires coordination and cooperation with the farmers(s) or other land owner(s). If large areas are to be used in the city or near the treatment plant, the solutions must be worked out in a close dialog with the people of Vadsbro.

For environmental reasons, it is naturally important to use existing infrastructure, e.g., sewage pipes, pump stations, and buildings, as much as possible.

Responsibility and monitoring

Wastewater treatment with nutrient recycling and the use of area-extensive (natural) systems require a different sort of monitoring and division of responsibility than is normally the case for water and wastewater systems.

For example, nutrient reduction cannot be monitored just by measuring flow and nutrient concentration measurements at defined points. Instead, ecosystem models and mass balance calculations must be used to determine the nutrient balance for the entire system. Using these tools, it is possible to estimate some of the parameters that cannot easily be measured, e.g., nitrogen loss to the air as ammonia.

Cooperating with farmers to operate the treatment system and use the sludge also requires different types of contracts and responsibility than is normal for wastewater systems.

New types of responsibility and monitoring do not necessarily lead to more work or increased expense. The question of responsibility could be solved through buying land, *or* renting it with a long-term lease, together with the use of contractors for the operation. The stability of natural systems in wastewater treatment means that there is also money to be saved through simpler monitoring and less frequent sampling and tests.

PRACTICAL CONSIDERATIONS

Best Available Technology (BAT) from practical and economical consideration:

ECONOMICS

- Cheaper than construction of a completely new system, i.e. maximum 4,000 USD/household.
- An average operational cost for small treatment plants, i.e. about 250 USD/household.

TECHNICAL FUNCTION

- A proven, robust system that gives few surprises. Surprises can lead to inadequate treatment and/or extra expenditures

FITTING IN WITH THE LOCAL SITUATION

- Goals of land owners and residents (if any) near the treatment plant. How do they want to use their land? Can they use resources from the wastewater, for example, in agriculture?
- Goals of other affected parties: i.e. low energy consumption and/or reduction in other resource use; multi-use facilities that combine wastewater treatment with open water and wildlife habitat.
- Use existing infrastructure when feasible

RESPONSIBILITY AND CONTROL

- New systems may require new divisions of responsibility between municipal wastewater engineers and farmers
- Discharge monitoring may be more challenging, and could require new methods for monitoring.

Amounts of water and pollution

Amounts of water

Today there are about 125 people connected to the treatment plant at Vadsbro. No great increase is expected. The figure of 140 persons will be used for planning purposes.

In 1994, there was a rather comprehensive revamping of the sewer system, which reduced the amount of leakage into the sewers. Flow measurements in the present treatment plant indicate that leakage has decreased by 30%. For 1995, the mean flow at the treatment plant was 320 l/person/day, which is twice as much as the measured water consumption. If this figure were accepted for the future, 140 people would lead to a mean daily flow of wastewater of 45 m^3.

Amounts of nutrients and pollutants

It is difficult and expensive to measure sewage flows accurately and analyse enough water samples to obtain representative data, especially in small treatment plants. The annual load of nutrients and pollutants can therefore best be calculated by standard values, that is, statistical averages from a normal population. Calculations from the Swedish Environmental Protection Agency have been used as a means for calculating the amount and composition of the wastewater in Vadsbro.

The wastewater contains little in the way of nutrients, compared with what is used in agriculture. For example, the total nutrients coming to Vadsbro's treatment plant are about equal to normal Swedish fertilisation rates for 4-5 hectares of grain. The wastewater's nitrogen is equal to normal leaching from 60-70 hectare of Swedish agricultural fields.

A kilogram of nitrogen or phosphorus pollution from agriculture is not necessarily the same as a kilogram from wastewater. Nutrients from agricultural land are lost primarily in the spring and fall, when the plants cannot take up the nutrients. Wastewater, on the other hand, flows continuously. During the summer, the nutrients cause eutrophication and thereby directly harm the receiving body of water. On the other hand, the nutrient-enriched water can be used as a resource during this period if used as irrigation water in crop production.

As mentioned above, it is important that the nitrogen in wastewater be nitrified before it is discharged. The ammonium nitrogen in today's discharge from the treatment plant in Vadsbro consumes as much oxygen in the recipient as the organic matter (BOD) in the raw sewage would, if it were discharged without treatment.

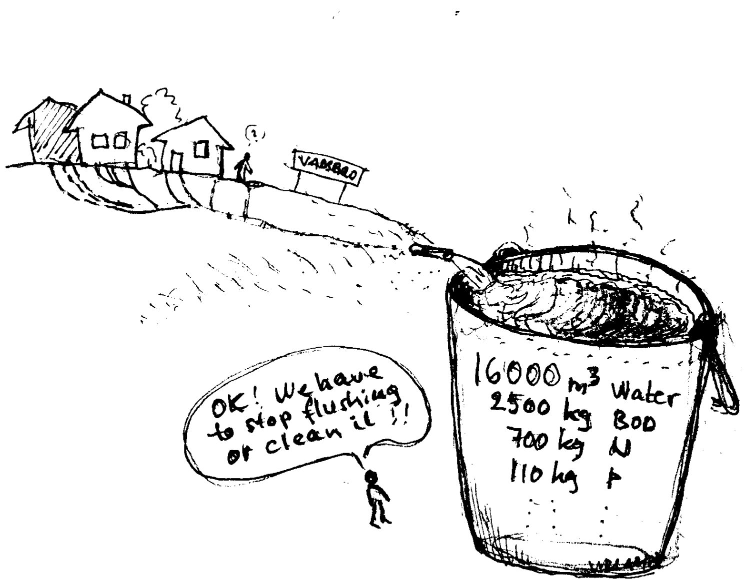
Pathogens, as well as organic compounds from cleaning agents or medicines in the wastewater, also need to be considered when designing and dimensioning the treatment plant. The effect that these organic compounds have on the environment is controversial. With an effective biological treatment in the treatment plant, many of these substances can be biodegraded and thereby rendered harmless.

WASTEWATER IN VADSBRO

NUMBER OF PERSONS
- Designed for: 140
- Today: 125

WASTEWATER FLOW
- 45 m^3/day average (320 l/person/day)

NUTRIENT AND ORGANIC MATTER FLOWS
Calculations from Swedish standard figures:
- Phosphorus: 110 kg/year
- Nitrogen: 700 kg/year
- BOD_7: 2 450 kg/year



Possible measures and principles for solutions

Generally, it is most effective to work proactively. For wastewater, this means preventing pollution from occurring. If nutrients are to be recycled to agriculture, they must be kept free from contaminants like heavy metals and organic toxins. Regardless of whether the wastewater is sorted at the source or mixed in the conventional way, it is important that the users be aware of the importance of adding only natural and environmentally benign substances to the wastewater system.

Alternatives at the source

All the on-site wastewater treatment options listed in the figure opposite are possible to build. They fulfil the general requirements for treatment discussed above, but all the alternatives are more expensive than the economic threshold set up in the requirements for treatment at Vadsbro. The situation was rather unusual at Vadsbro, however, where the existing sewer system had recently been renovated. In situations where both the sewer system and the treatment plant need to be rebuilt or renovated, on-site alternatives would be more economically competitive.

Furthermore, for centralised systems there are well known administrative and legal routines. These kinds of routines have not yet been developed in Sweden for decentralised systems (although they are in use in Norway). Thus, due to costs, legal and practical constraints the alternatives involving measures at the source were ruled out early in the planning process in Vadsbro,

End-of-the-pipe alternatives

The sewered region in Vadsbro is small and easily monitored. Only households are connected to the system. These conditions help ensure that the nutrients in the system can be kept so free from contamination with heavy metals and other poisons, that they can be recirculated to agriculture.

The six end-of-the-pipeline alternatives in the figure all meet requirements for hygiene, protection of the recipient, and resource management, as well as the practical and economical requirements suggested in the terms of requirements. They are listed in order of increasing technical intensity; that is, those alternatives listed first require less artificial help in the form of chemicals and energy. A trade-off is that the alternatives earlier on the list need a greater land area.

The wastewater treatment in an ecocycle perspective is complete when the nutrients, or at least phosphorus, has been returned to agriculture. Alternative 4, the wetland-agriculture rotation, has no problem meeting this requirement since it is a complete ecocycle system in itself. In order for the others to meet the ecocycle requirement, there must be transport of the nutrients to agriculture. For Alternative 1 (energy forest), the nutrients are in the form of sedimentation sludge and ash, while in Alternative 2 (calcium precipitation pond) and Alternative 3 (biofilter ditch), sludge and sediment are returned to agriculture. For Alternative 5 (sand filter), the substance transported is sand saturated with phosphorus, while for Alternative 6 (package (compact) treatment plant), sludge precipitated mechanically, biologically, and chemically is returned.

POSSIBLE SOLUTIONS IN THE SYSTEM

A. ALTERNATIVES AT THE SOURCE

1. Mixed wastewater, septic tank, and further treatment in a sand filter with high phosphorus sorption capability.
2. Composting toilet. Graywater treated locally or centrally.
3. Blackwater separation, very low-flush toilet, and collection in tank, with transport to agriculture. Graywater treated locally or centrally.
4. Urine separation in a double-flushing toilet. Collection in tank, with transport to agriculture. Faeces and graywater to a septic tank and further treatment in a sand filter.

B. ALTERNATIVES AT THE END OF THE PIPE

1. Primary treatment, storage, and forest irrigation.
2. Stabilisation ponds with chemical (calcium hydroxide) precipitation
3. Primary treatment, trickling filter, and biofilter ditch.
4. Primary treatment, trickling filter, and crop/wetland rotation.
5. Primary treatment, sand filter, and biofilterditch/wetland.
6. Package treatment plant (sequence batch reactor, SBR) including nitrification, followed by a biofilterditch or wetland

Alternatives at the source

Alternative 1: Adsorption of P in a reactive filterbed

This alternative requires a minimum of change in the house. The on-site treatment system does require construction in the yard, but the constructions can be nearly invisible once built.

A three-chambered septic tank is used for primary treatment. The aerobic biological treatment is performed in a sand filter, or in a constructed wetland. To achieve high phosphorus removal, a filter medium is used which contains iron, aluminium, or calcium.

Phosphorus sinks have been used more ore less successfully in decentralised applications in recent years. More research and development work is however needed to make this technology commercially available for single households. The technique with open filter beds is described in more detail under end-of-pipe solution, alternative 5, below.

Alternative 2: Composting toilet

Composting toilets (also called biological toilets) require quite a large space if the biological process should be kept reliable. With separate treatment of urine and faeces, most of the nutrients and potential pathogens are removed from the wastewater. In the graywater there is still larger amount of BOD. Therefore, the main purpose of the graywater treatment is to get rid of these organic compounds that otherwise may cause odorous. Treatment with a septic tank followed by an aerobic sand filter is appropriate for the graywater. The septic tank and the sand filter can be 25-30% smaller than if they were to be used for mixed wastewater.

Food waste from the kitchen can also be put into the composting toilet, eliminating the need for separate treatment. This can result in considerable cost savings.

Experiences with compost toilets show that operating problems, like odorous and flies can easily occur if not the biological process is probably maintained. However, if a composting toilet is managed correctly the system is very efficient in terms of hygiene and environmental aspects.

Alternative 3: Blackwater separation

This alternative requires replacing the pipe system and room for placement of a collection tank. Low flush toilets (< 0.5 l/flush) with ordinary toilet technology can transport toilet waste 15-30 m. For longer distances, vacuum toilets or larger amounts of flush water for faeces are needed.

Organic kitchen waste can be treated together with toilet waste. For hygienic reasons it is recommended to treat this in a biogas facility or a liquid composting reactor.

The system is as a whole very interesting, both economically and environmentally. There is some experience with all components in the system, but limited experience with coordinating them.

Alternative 4: Urine separation

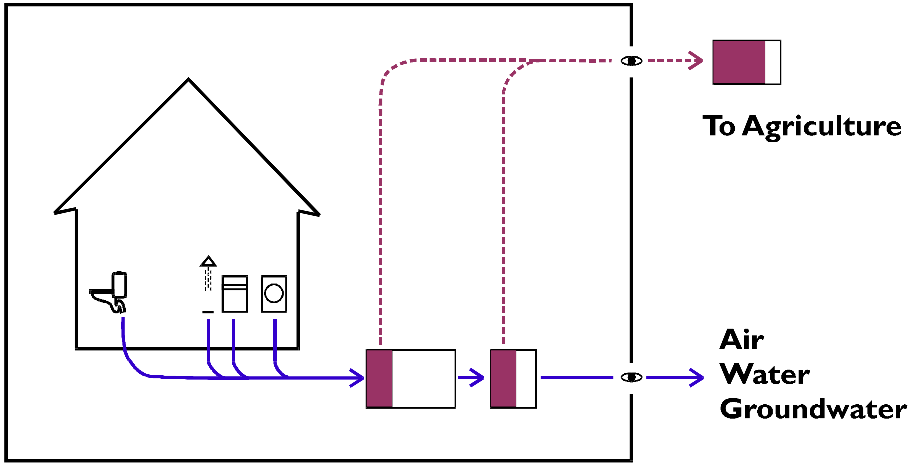
It is simple to renovate existing systems to install this alternative. The toilet is replaced with an urine separating stool, and a new, separate pipe or hose is installed to a collection tank. This urine pipe should have a minimum diameter of 40 mm, so that it can be flushed free of biological and mineral build-up.

Since the faeces are channelled to the same treatment system as the graywater, the requirements for treatment (especially of hygienic reasons) are higher than for the system for only graywater.

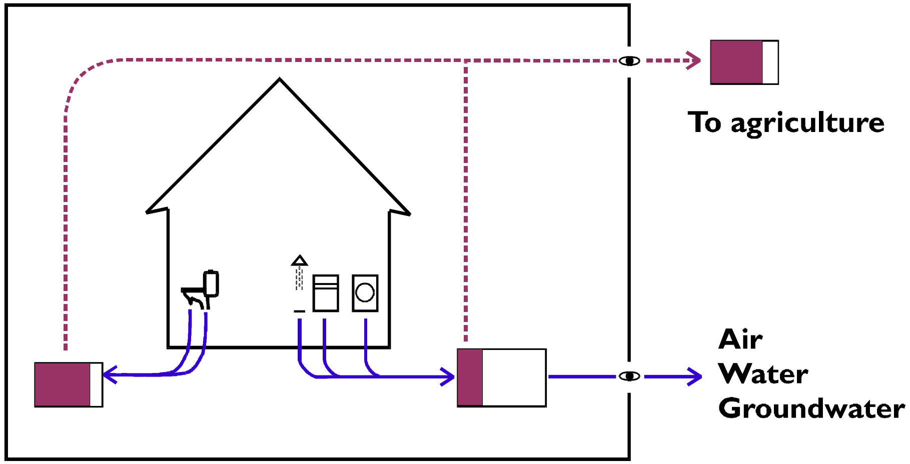
The urine has to be stored for a number of months to achieve sufficient pathogen die-off.

This solution is relatively well tested and evaluated, and has a potential to be robust. The degree of recirculation for this alternative is second only to that for blackwater separation.

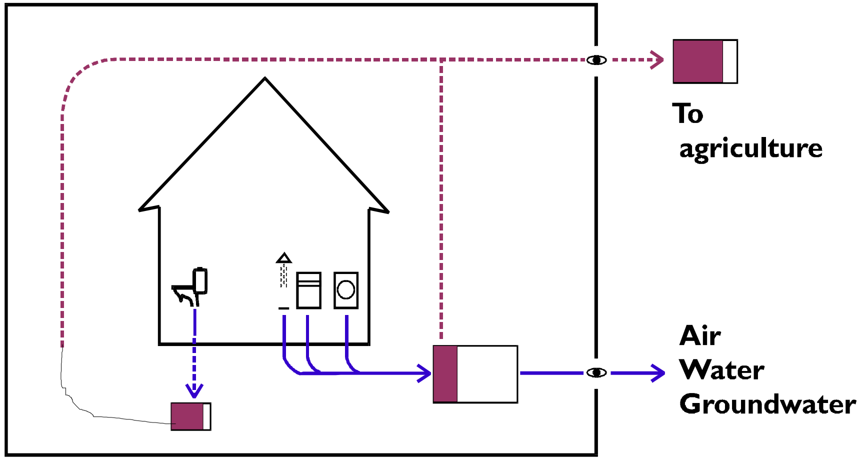
Alternative 1. Adsorption of P in a reactive filterbed



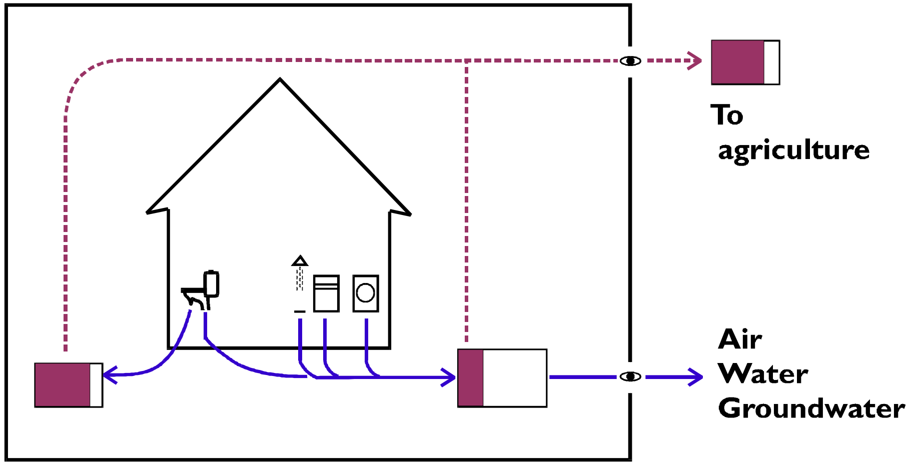
Alternative 3. Separation of blackwater



Alternative 2: Composting toilet



Alternative 4. Separation of urine



Alternative 1: Treatment with energy forest irrigation

In this alternative, sewage flows a primary treatment step located just before the present pumping station. After primary treatment, the water is pumped to a long-term storage pond, where the water can be stored over the winter for irrigation in the forest during the summer. Willow, alder, poplar, and birch are all trees suitable for irrigation. If the trees are harvested for energy (wood chips for boilers), they can be harvested frequently, e.g., every 4-6 years. If the trees are cultivated for timber or wood pulp, a rotation of 25-30 years could be feasible. So far, forest irrigation has only been used for wood chip production from willow.

Engineering and dimensioning

For primary treatment by sedimentation and flotation in a treatment plant, the hydraulic load (load water to the surface) should not exceed 1,5-1,9 m^3/m^2 per hour. The normal daily flow is 45 m^3 in Vadsbro, but a major part of this water is produced during the morning and afternoon. In a small system like this, only serving households, it is normal to divide the mean daily flow by 5 to 10 hours to get the water flow for dimensioning (q_{dim}). The choice of figure depends on the specific flow pattern in the system.

Using the estimated q_{dim} for Vadsbro: 45 m^3/5h = 9 m^3/h, and the dimensioning criteria of 1,5 m^3/ m^2 x h we can calculate the minimum surface area to 6 m^2 needed for pre-sedimentation in Vadsbro. The depth of the pre-sedimentation should not be less than 2,5 m. Besides the volume for sedimentation, volumes for sludge storage must also be reserved.

The irrigation reservoir ought to hold seven month's flow, about 10,000 m^3. The volume ought to be divided into sections, so the "oldest" water is always removed for irrigation. It is advantageous to make the reservoir deep, to keep nitrogen and phosphorus in solution. With a depth of 3 m, a surface area of 3,000-4,000 m^2 is needed. An appropriate location is the agricultural field below the treatment plant.

The amount irrigation in the forest is determined primarily by the amount of the limiting nutrient (phosphorus, in this case), and secondarily by the amount of water. As is apparent from the figure, about half the phosphorus is calculated to settle in the reservoir, so that approximately 50 kg of phosphorus will come to the forest. With a calculated annual biomass production of 12 tons of dry matter per hectare, 11-12 kg phosphorus per hectare will be extracted from the system annually in the harvested biomass. This means that it is possible to supply approximately four hectares of forest with the wastewater's nutrients.

Spread on four hectares, the annual production of 16,000 m^3 of wastewater gives a dosage of 400 mm per season, which is close to the optimal irrigation level for an energy forest in this climate.

Reduction and recycling

Since a closed hydrological cycle is created, there is in principle zero discharge. A small amount of nutrients, in the form of nitrate nitrogen or particulate phosphorus, will, of course, leak out of the system, as is the case with all cultivated land.

It is unclear how close this is to an ecocycle system, since the nutrients are not returned to land for food production. If the forest is used as energy forest, however, the phosphorus-rich ash can be used as fertiliser after combustion.

Hygiene

With long storage times and low-pressure irrigation from nozzles near the ground, the risk of pathogen spreading can be reduced. Security is increased even more if irrigation is only performed at night. The hygienic risks do, however, pose some uncertainties for this alternative, as the land to be irrigated is relatively near residences, and Sweden has little experience with or guidelines for irrigating with wastewater.

Local adaptation

The energy forest would be a new element in the landscape, and would probably be considered undesirable by nearby residents. It would block a scenic view for many of them, and keep them out of a field that they might use for skiing, etc. during the times of the year when crops were not on it. This, together with the hygienic uncertainties, argues against the energy forest alternative.

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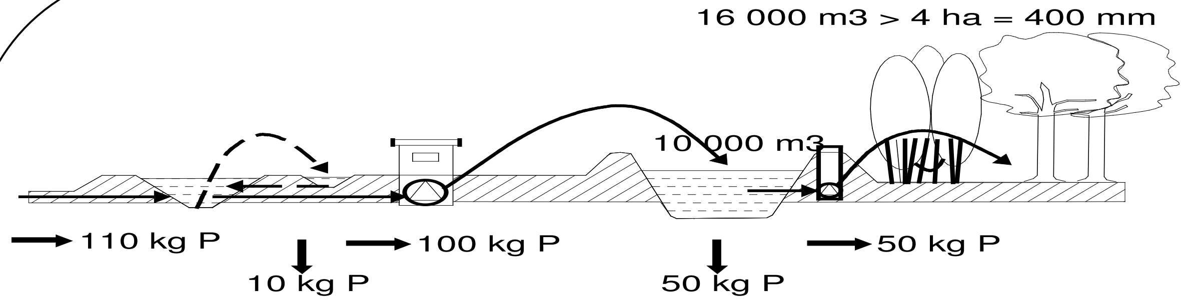
PRIMARY TREATMENT, STORAGE AND FOREST IRRIGATION



	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>95%	>95%	>95%	Very high
Recycling:	<50%	<50%		

Health risks:
- Probably can be made low
- No national guidelines for this practice

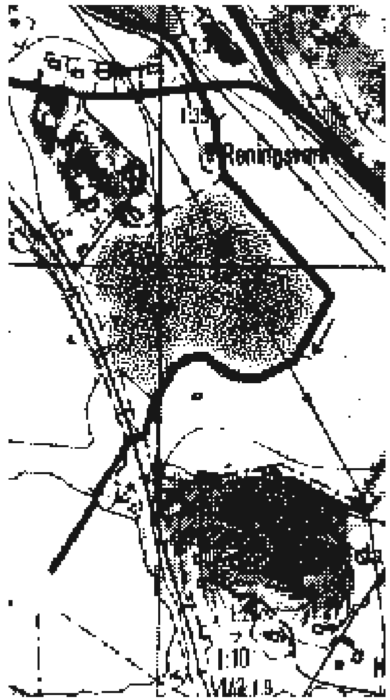
Economics: Inexpensive
- Pre-sedimentation: 20,000 USD
- Irrigation reservoir: 25,000 USD
- Energy forest: 25,000 USD (incl. pipes, etc.)

Local suitability:
- Large, probably negative visual impact
- Health impact on near neighbours cannot be guaranteed

Responsibility: Requires long-term leasing of land

Control: Through budget calculations

Other: New method, used only a few other places



Alternative 2: Stabilisation ponds with chemical (calcium hydroxide) precipitation

Precipitation using slaked lime (calcium hydroxide, or $Ca(OH)_2$) can be designed into a stabilisation pond for a simple and robust method of cleaning wastewater in situations where it is possible to build open ponds and to handle large volumes of sludge.

In this method, the water goes first to a brief primary treatment and then is pumped to the stabilisation pond, where the slaked lime is added as the water flows in. The slaked lime raises the pH and flocculates and precipitates the particulate matter and phosphorus.

Engineering and dimensioning

The precipitation process is rather insensitive to the water's content of suspended particles, but a brief primary treatment facilitates both pumping and addition of the slaked lime. There ought to be at least one hour detention time in this step, which for a Q_{dim} of 45 m^3 means 4 m^3 volume, plus room for the primary sludge.

The slaked lime is added via a screw pump, and the lime reacts with the phosphorus in the water to produce calcium hydroxyapatite ($Ca_5(PO_4)_3OH$). Slaked lime consumption is 0.3 - 0.6 kg per m^3 wastewater, depending on the water's alkalinity.The stabilisation pond should be overdimensioned, so it will not be sensitive to uneven flows or short interruptions in the addition of the lime. A detention time of approximately ten days is desirable, which means the necessary pond volume is at least 250 m^3 plus the volume occupied by the sludge. This volume ought to be divided into two ponds, so that one can be emptied without disrupting the operation of the other. Long, narrow ponds give the most favourable hydraulic conditions (they prevent short circuits in the flow) and they can (and should) also be built to be easily accessible for vehicles and equipment used in cleaning out the sludge.

Depending primarily on the detention time, 4-10 l sludge will be produced per m^3 wastewater. This means that the plant must include sufficient space to store and dewater an annual production of 65-165 m^3 sludge.

Reduction and recycling

More than 90% of the phosphorus in the wastewater could be removed with this method, which gives an effluent concentration of 0.5 mg/l P. Most of the BOD in wastewater is in suspended solids, which are removed in both the primary treatment and the precipitation step. Of the nitrogen, the majority of the organically bound fraction will flocculate and fall to the bottom, while a significant part of the inorganic nitrogen may volatilise as ammonia. With pH at about 11 and a detention time of 10 days, a nitrogen reduction of 50% can be expected in the water.

Sludge from the slaked lime precipitation is an excellent phosphorus fertiliser for acidic to neutral soils.

Economics

The investment cost is low, while operating costs can be high, as much supervision and management are needed.

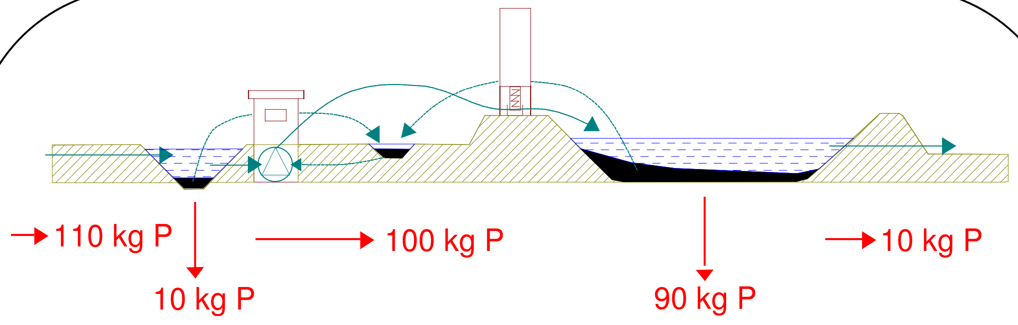
Hygiene

In the high pH (10.5-12) necessary for precipitation, bacteria and viruses are reduced rapidly and effectively both in the water and in the sludge created. The method can therefore be seen just as much as a method for sanitising the wastewater as for removal of phosphorus, organic matter, and other substances. Smell is not a problem during normal operation, although odours can occur during sludge removal.

Other

The method has much to commend it. Amongst the disadvantages are problems with slaked lime dust causing skin problems and breathing difficulties in the workers, plus the relatively large need for supervision, since the lime can get stuck in the storage silo or clog the dosing apparatus.

STABILISATION PONDS WITH CHEMICAL (CALCIUM HYDROXIDE) PRECIPITATION



	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>90%	50%?	>90%	High
Recycling:	<90%	<20%		

Health risks: Acceptable

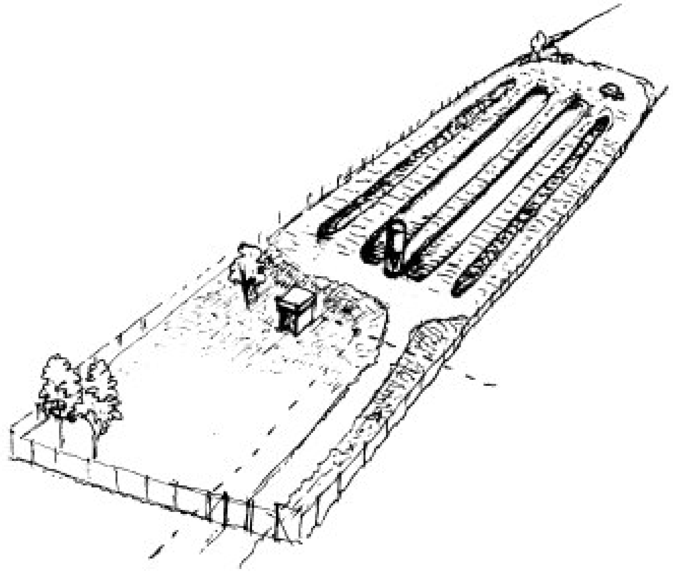
Economics: Inexpensive to build (totally 55 000 USD), more expensive to operate

Local suitability: Good

Responsibility: Requires buying land

Control: Simple to operate

Other:
- Robust and well tested
- Great potential for phosphorus recycling



Alternative 3: Treatment in a biofilter ditch

In this alternative, a long, thin wetland, like a ditch, is formed and placed parallel with the present river. Most of the reduction of phosphorus, nitrogen, and pathogens will take place in this biofilter ditch. For this to work properly, sediment and plant litter must regularly be removed from the ditch. In addition, a thorough pre-treatment is required to reduce levels of micro-organisms, BOD, and ammonia.

Engineering and dimensioning

Wastewater is piped to the pump station and pumped to primary treatment. From there it is pumped to a recirculating trickling filter, that is, the water is circulated several times through the filter bed. Recirculation dilutes the incoming wastewater, and the lower initial levels of BOD and ammonium provide more favourable conditions for the nitrifying bacteria in the biofilter. In order to achieve nitrification, the trickling filter's capacity for BOD reduction should be at least 2 g BOD5 per m^2 of medium surface area. With a BOD loading of 2000 g/day, the surface area of the medium needs to be 1000 m^2. If the medium has a specific surface area of 150 m^2/m^3, then a filter volume of 6-7 m^3 is needed.

The production of biofilm in the trickling filter, together with the sludge collected in the primary treatment, give a significant (approx. 30%) reduction in N and P. Thus the bioditch receives approximately 80 kg phosphorus with the wastewater. A new wastewater wetland built in clay soil has high phosphorus retention, partly because of chemical sorption and precipitation, and partly because of biological fixation in bacterial and plant biomass. If the ditch is built with a bottom area of 3.5 m^2 per running meter, a surface area of 1,750 m^2 can be created with the 500 m available. In order to obtain 90% reduction of phosphorus, 40 grams of phosphorus must be captured per square meter annually. This level of removal is comparable to the results from three years of operation of the biofilter ditch in the southern part of Sweden, as well as the wetland in Oxelösund (100 km south of Stockholm), Sweden.

The calculated retention time in the biofilter ditch, without considering the losses from percolation and transpiration, is about 14 days, which is three times longer than the retention time in the plant in southern Sweden and twice as long as at the wetland in Oxelösund.

Reduction and recycling

Reduction of BOD, phosphorus, and nitrogen meets the previously discussed requirements. With a high (25-50%) nitrification in the trickling filter and periodic cleaning of the ditch it is possible to guarantee an efficient reduction of P. Denitrification in the bioditch is sufficient to convert all the nitrate produced in the trickling filter to nitrogen gas. The long retention time will help to reduce the level of nutrients and faecal microorganisms in the ditch effluent to that of normal surface waters.

Recycling of nutrients is high. Sludge and material removed from the biofilter ditch are piled in mounds for dewatering and stabilising, and can later be spread on agricultural fields nearby with normal manure spreaders.

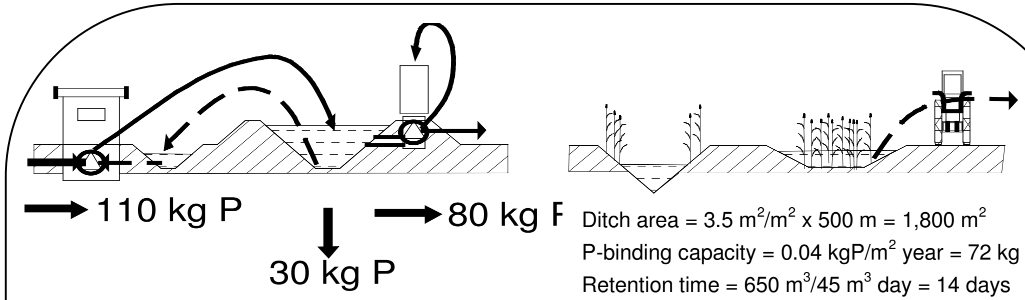
Economics

Construction costs for bioditches are very low. It is also advantageous that the existing sedimentation basins in the pump station and treatment plant can be used for sedimentation, while the existing building can be used to protect and isolate the trickling filter.

Other

The system is well suited to the local area and is easy to integrate with the present land use patterns. It is also inexpensive and flexible. One example of flexibility is the possibility of adding flocculants like aluminum or calcium in any of several steps, to enhance phosphorus removal.

PRIMARY TREATMENT, TRICKLING FILTER AND BIOFILTER DITCH



	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>90%	>50%?	>95%	Very high
Recycling:	up to 90%	up to 50%		

Health risks: Low. Better control than today's system

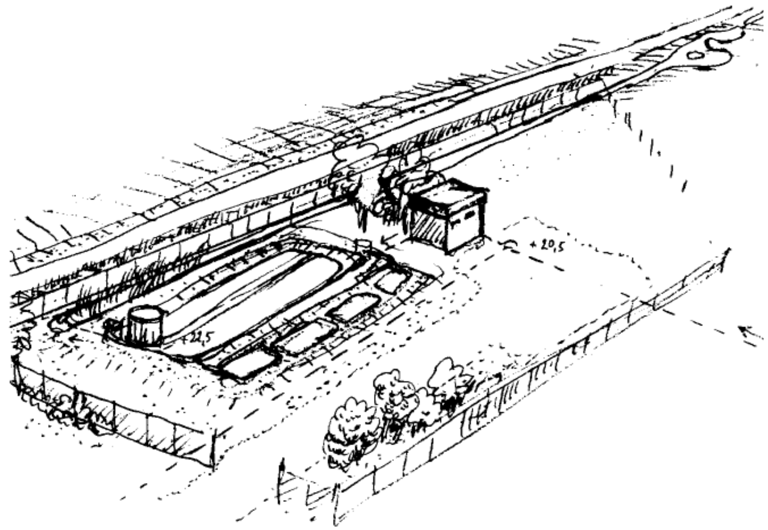
Economics: Very inexpensive
- Pre-sedimentation: 20,000 USD
- Trickling filter: 12,500 USD
- Biofilter ditch: 20,000 USD

Local suitability: Good

Responsibility: Easy to formulate in contract

Control: Easy to test

Other:
- Interesting low-tech method
- Can be supplemented with other methods



Alternative 4: Treatment with crop-wetland rotation

There are examples—both historically and, in warmer and temperate climates, even today—of periodic changes of a field's use between crop production and wastewater treatment. There are also similar systems with irrigation and crop production without periodic changes in use today in Europe. While this has not been tested in Sweden, shifting between wastewater treatment and crop production seems so well suited to meeting the treatment requirements for Vadsbro that this method has been included as an alternative to consider.

The system should involve rotation between a constructed wetland for wastewater treatment and production of conventional crops like grain or oil-seed plants. The wetland period should be begun after the harvest of the crop, in the late summer or fall. Application of water is done to the upper part of the field, which as a whole is flooded with several decimetres of water. During the flooding period, the wastewater treatment processes are the same as those for the bioditch (Alt. 3) described above.

The wastewater wetland phase ends the following August, to give time for drying out and soil preparation. If possible, the crop is sowed that same autumn. During the following year, when the field is used for conventional agriculture, the stored nutrients are utilised by the crop. This method does more than reduce the use of chemical fertiliser. The need for weed control is also reduced, as the periodic, long floods kill terrestrial weeds.

The wastewater treatment should be more effective in this crop-wetland rotation system than in an ordinary constructed wetland, since the crop residue in this system provides a carbon source and physical substrate for microorganisms. Also, the capacity for binding phosphorus and nitrogen is renewed through the periodic cultivation.

Engineering and dimensioning

In order to improve the water's hygienic quality, it can be pretreated in a trickling filter. With both primary treatment and trickling filter, about 30% of the phosphorus will be removed in the sludge. This sludge can be dewatered on site in drying beds.

The wastewater has enough nutrients for four hectares of wetland-agriculture rotation, with three fourths of the area in agriculture and one fourth flooded at any given time. This is calculated from the amount of phosphorus in the harvested and removed crop parts plus the conversion of phosphorus to insoluble forms (soil fixation).

Reduction and recycling

Reduction of phosphorus, nitrogen, BOD, and persistent organic compounds is very high in this system. Recycling of phosphorus and nitrogen is also very high.

Economics

The wetland-agriculture rotation, in contrast to the other systems described here, comprises a complete ecocycle, since recirculation of the nutrients is part of the system design. Because of this, wetland-agriculture rotation is very inexpensive. Economic synergy effects ensure that both the agriculture and the sewage treatment ought to be less costly, compared to doing either one separately.

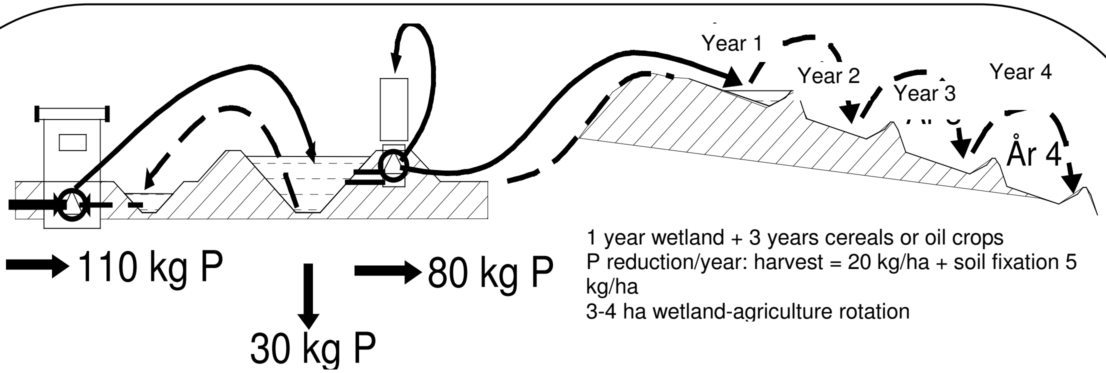
Significantly higher operating costs are possible if very strict hygienic standards are set for the pretreatment.

Other

In Vadsbro the land available outside the present treatment plant is well suited for wetland-agriculture rotation, with appropriate topography, soil type, and area.

The chief disadvantage of this rotation is that it is untested. In Vadsbro, with housing so near the fields that would be used, this method could create unacceptable hygienic risks, even with the trickling filter pretreatment, and odour problems. These objections are enough to override the method's other advantages.

PRIMARY TREATMENT, TRICKLING FILTER, AND WETLAND-AGRICULTURE ROTATION



	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>90%	>90%	>95%	Very high
Recycling:	Up to 90%	Up to 25%		

Health risks: Low to questionable

Economics:
- Inexpensive, with profits from synergy with agriculture
- Pre-sedimentation: 20,000 USD
- Trickling filter: 12,500 USD
- Crop/wetland rotation: 25,000 USD

Local suitability: Good, but risk of conflict with neighbours

Responsibility: Requires long-term leasing of land

Control: Through budget calculations

Other: Untested. A further development of existing wetland technology

Alternative 5: Treatment in a sand filter

In this alternative, most of the treatment process takes place in a sand filter, which is responsible for breakdown of organic matter, phosphorus retention, and nitrification of nitrogen compounds. Small ponds can be added as a wetland polishing step, mostly for nitrogen reduction through denitrification.

Engineering and dimensioning

Primary treatment is used for suspended solids (SS) and BOD removal, as described for Alternative 1. The pretreated water is pumped to the sand filter, where it is spread over the surface. The surface is divided into sections, both in order to facilitate water distribution and so that some sections can periodically be rested, to regenerate their infiltration capacity and phosphorus binding capacity.

The dimensions of the bed are determined by the water flow during the high water periods, which we assume to be 70 m^3/day. For this to correspond to 100 mm per day, the sand filter needs to be 700 m^2. The depth is less important, since all treatment processes occur in the 1-2 dm top layer, but standard practice is that the bed should be built with at least a one-meter percolation layer.

The bed is built partially buried in the ground and bermed with soil. To fulfil the desirable requirement of 50% nitrogen reduction, a polishing step for denitrification is necessary. If 30% of the nitrogen is assumed to be reduced in the pretreatment and sand filter, then another 140 kg must be denitrified afterwards, e.g., in a pond or biofilter ditch. This requires 600-800 m^2 of additional area.

Reduction and recycling

Reduction of all pollutants and nutrients is stable and very good with treatment in a sand filter. Of all the alternatives discussed, the sand filter is rated best for pathogen removal. Possibilities for recycling the nutrients are more difficult to judge. Even if all the phosphorus-saturated sand is spread on agricultural land, a smaller amount of the phosphorus will probably be available to plants due to phosphorus precipitation into insoluble minerals. For other nutrients, only those quantities that are captured in primary sludge can be returned to agriculture.

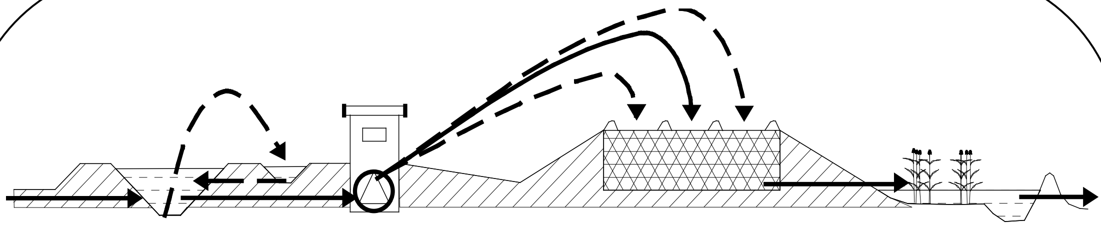
Economics

The alternative is probably more expensive to build than those previously discussed. Operating costs are quite small, since no chemicals or aeration is used, and there is little need for maintenance.

Other

The alternative has the advantage that the technology is tested. In comparison with the other alternatives, one can say with certainty that the pollutant removal will be high and stable. The system is also easy to isolate, and it is therefore easy to control and measure inflow and outflow.

The primary disadvantage to this alternative is the cost. It also requires a fair amount of area. Odour problems ought to be avoidable but might nonetheless occur.



Q_{dim} = 70 m^3/day
100 mm/day means 700 m^2

	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>90%	>50%	>95%	Very high
Recycling:	Up to 90%	Up to 15%		

Health risks: Low. Better than package treatment plant

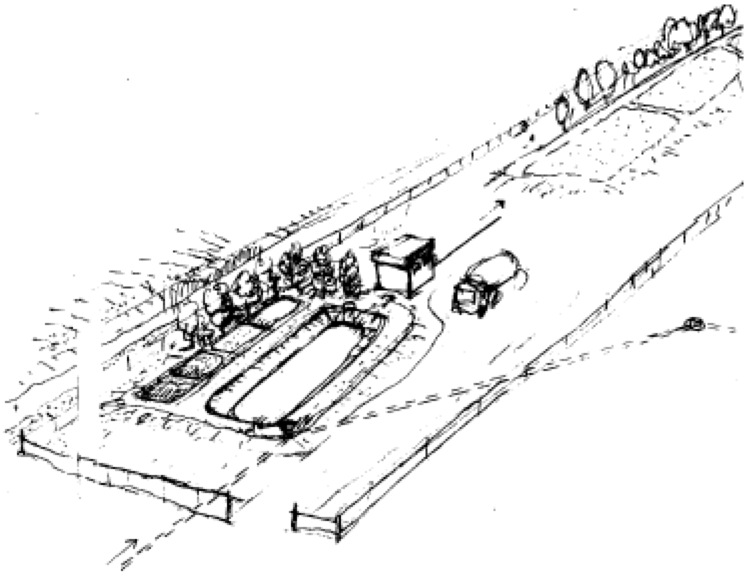
Economics: Medium cost level
- Pre-sedimentation: 20,000 USD
- Sand filter: 125,000 USD
- Biofilter ditch or wetland: 3,000 USD

Local suitability: Unusual use of landscape

Responsibility: As for an ordinary treatment plant

Control: Measurements are easy to perform

Other:
- Requires regular renewal of surface layer
- Proven method



Alternative 6: Treatment with a package treatment plant

A package treatment plant is a prefabricated module with the entire treatment contained in a building. There are several on the market which can fulfil Vadsbro's general requirements for treatment, when combined with polishing in a wetland for reduction of pathogens and nitrogen.

Since the wastewater flows are small and uneven, batch treatment in a sequenced batch reactor (SBR) is preferable. After primary treatment, a batch of wastewater enters the SBR, where biological treatment is promoted through bubbling in air and chemical treatment is carried out by dosing with chemicals. After every treatment cycle, the sludge is removed from the reactor.

Reduction and recycling

The performance of package treatment plants has improved over the last ten years. Batch technology and computer control of the treatment process give relatively stable operation, even with varying flows and temperature. The numbers given in the figure are those usually provided by the manufacturers.

Economics

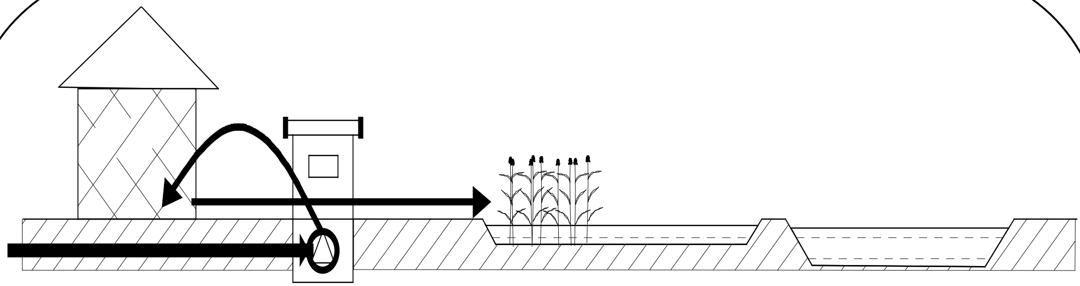
Investment costs for package treatment plants are usually competitive with or more expensive than sand filters. The operating costs are, however, considerably higher, since the treatment consumes a good deal of precipitation chemicals, as well as much electricity for the air pumps, water pumps, and heating.

The costs given here do not include building the structure over the treatment plant.

Other

A package treatment plant is a simple alternative, from the point of view of planning and administration. It requires neither special modifications for any given locale nor coordination with any other land use. On the other hand, there are no possibilities for cost savings or other effects from synergies with other systems.

PACKAGE TREATMENT PLANT PLUS BIOFILTER DITCH OR WETLAND



	Phosphorus	Nitrogen	BOD	Org. toxins
Reduction:	>90%	>50%	>95%	Good
Recycling:	Up to 90%	Up to 15%		

Health risks: Low, after the biofilter ditch or wetland

Economics: Medium to high cost level
- Package treatment plant: 125,000 USD
- Biofilter ditch or wetland: 3,000 USD

Local suitability: Little noticeable change in land use

Responsibility: As for an ordinary treatment plant

Control: Simple measurements

Other: Requires regular supervision and continual inputs of energy and chemicals

Afterword: The decision in Vadsbro

The goal for the planning work in Vadsbro was to produce many alternatives, which could meet the requirements for hygiene, pollutant removal, and recycling, within economic and other constraints. Many ideas were discussed, but most of them were rejected early in the planning process. Among the rejected alternatives were all of those that required changes at the households being served, i.e. solutions at source. This was in large part because one of the major investments of centralised solutions, the sewer system renovation, had already been made. Using this investment was seen as less expensive than building new solutions at the source.

The six end-of-pipe solutions presented in this report, however, all meet Vadsbro's requirements. Costs and other consequences have been projected in feasibility studies for all six alternatives. A wastewater engineering consultant (WRS) performed the studies in cooperation with the municipality's department of civil works (which owns the present treatment plant) and the Environment Protection and Public Health Committee (the regulatory authority).

For the politicians, this report made clear that there can be widely varying technical means to achieve the goals that had been set up in the initial requirements. This came as a surprise to many of them.

How were they to decide amongst the alternatives? First they had to understand each one sufficiently to see its most important consequences, and then visualise the ways the alternatives compared with one another. Presentations with simple sketches, such as we have included in this booklet, showed how each method works and what impact it would have on the landscape. Describing the consequences of each alternative in terms of the categories of the initial requirements (hygiene, etc.) made the suggestions easy to compare.

After a short discussion, the Environment Protection and Public Health Committee decided on alternative 3, treatment with a biofilter ditch.

Considerations of cost and risk were decisive for the municipality's decision. A summary is showed on next page.

Alternative 3 was chosen because it was an inexpensive and robust way to meet the initial requirements. Alternative 6, the package treatment plant, had previously been the favoured alternative, but the biofilter ditch was seen as both significantly less expensive and more effective for both pollutant reduction and nutrient recycling.

Compared with the other alternatives, the biofilter ditch was given points for using minimal amounts of materials and other resources, making a smaller mark on the landscape, and its limited need for operation and supervision. The committee was uncertain whether the treatment would function well enough. It was therefore seen as a significant advantage that phosphorus removal could be improved, either through adding chemical precipitation to the primary treatment or putting limestone gravel in the biofilter.

In 1998 the constuction of the biofiltersystem started. Since the system in some respect represent a new and unproved concept for wastewater treatment in Sweden, the ambition is to follow up the results by an extensive monitoring program.

For more information, contact the municipality of Flen:

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Tekniska kontoret
S-642 81 Flen

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Final evaluation when comparing the alternatives

	Alt. 1 Irrigation	Alt. 2 Ca-precip.	Alt. 3 Bioditch	Alt 4. Rotation syst	Alt. 5 Sandfilter	Alt 6 Treat. plant
Economy	+++	+++	++	++	-	--
Reduction	+++	++	++	++	++	+
Potentials for recycling	++?	++	++	+++	++	++
Hygienic safe	-	++	++	-	++	-
Local adaptation	--	+	++	++?	+	++
Responsibility /Control	-	++	++	-	+++	+++
Conclusion	Very efficient and cheap but hygienic hazards Landscape impact	Efficient Robust service demanding	Efficient Cheap Flexible Robust	Not proved but very interesting	Efficient but quite expensive	Not cost efficient Simple planning

WASTEWATER TREATMENT IN A SMALL VILLAGE

Options for upgrading

By Peter Ridderstolpe, WRS, Sweden.
A company in the SwedEnviro Consulting Group.

Today many of the sewage systems constructed in Sweden have reached a point where renovation or upgrading is required. Many small- and medium-sized settlements need to upgrade existing sewage systems to more efficient and robust facilities. The need for upgrading is urgent, not only in Sweden, but also in many countries of Central and Eastern Europe.

This booklet is based on a real case of planning and construction of a reconstructed sewage system in a small village, Vadsbro, in the municipality of Flen, Sweden. It presents some alternative wastewater techniques, with focus on the entire sewage system from the source to the end of the pipe. It describes the planning process, and possible solutions focused on the goal to find a sustainable, efficient and low-cost solution for purifying the sewage.

Here you can read about alternatives such as:

- Treatment with forest irrigation
- Treatment with stabilisation pond with lime(Ca) precipitation
- Treatment with a biofilter ditch and wetland/crop rotation systems
- Treatment with open sandfilter systems
- Treatment with a package treatment plant

Mr **Peter Ridderstolpe**, WRS ekoteknik AB, M.Sc. in BioGeo-sciences at the University of Stockholm 1979, Lic. of Tech. in Applied Ecology at the Royal Technical University in Stockholm 1988. Peter works in the field of wastewater treatment, especially connections to recycling and natural purification processes. He is experienced in both conventional technologies and new and innovative technologies for small- and medium-sized systems.

Peter has in Sweden been at the frontline for source-separating toilet technologies such as urine-separation and blackwater system. He is well-known as one of the creators of the first full-scale wetland system for nitrogen removal of municipal wastewater. Since the last ten years Peter has worked as a consultant in co-operation with research institutions and engineering companies with planning, prospecting and construction of wastewater systems.

SWEDENVIRO consulting group

www.swedenviro.com

SwedEnviro Consulting Group is an association formed by Swedish environmental consultants companies, within the fields of waste, wastewater, and water management. The companies are, at present, Vattenresurs AB, Verna Ekologi och Miljökonsult AB, WRS Uppsala AB and WRS mark och vattenvård.

Coalition Clean Baltic

In Helsinki, February 1990, non-governmental environmental organisations from nine countries of the Baltic Sea Region united and established the Coalition Clean Baltic (CCB) in order to co-operate on activities for protection of the Baltic Sea environment. CCB is a politically independent, non-profit association. Currently CCB unites 24 member organizations from Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. CCB is gathering, producing and distributing information about environmental solutions for the Baltic Sea area. CCB co-operation project, help the member organizations to combine their efforts in the attempt to restore the Baltic Sea. Eco-technologies for wastewater treatment is one of the CCB Priority Activities.