Portfolio Water - Tom Boesten

Cleaning of waste water by intermediate technology

Identification of the problem

When it comes to water management in the Netherlands, everything is big. In the entire country every aspect of water is part of a man-made system. The water level of every river, lake and ditch is monitored and managed. The treatment of waste water is no exception. There is hard path technology everywhere. This brings us to the question if there is any place for intermediate technology. Is it needed, can it be better than hard path solutions? Our question here will be: can the Netherlands, or communities within the country, deal with waste water by means of intermediate technology, or are there only hard path solutions?

Why is it a problem?

Hard path solutions work very well in the country. Everybody has access to drinking water, in abundance. Nearly all households are connected to the sewage system, and the protection from flood by rivers or the sea has high priority for the government. The hard path technology that is developed, is even an export product: Dutch companies were contracted after the hurricane Katrina destroyed parts of New Orleans.

These solutions work so well, that the population is hardly aware of the necessity of dealing with fresh water in a responsible way. One reason to try developing soft path solutions is the value of raising awareness about the value of fresh water, and of raising commitment to the careful use of water.

A very different reason is global warming. This challenges the water management in numerous ways. The most dramatic effect of it is sea level rising. This will put in danger the mere existence of the country, half of which lies on or below sea level. But climate change also has an effect on the cleaning of waste water. Patterns of precipitation are changing. Heavy rains and, on the other hand, long periods of drought, occur much more often than they used to do. As a result of urbanisation, in the last century an increasing part of the surface has been paved. Rain water that falls upon houses, buildings or this paved surface, is drained through the sewage system. In times of heavy rains, the water treatment plants cannot cope with the quantity of water and they are forced to release water that is not cleaned at all or only half. In times of drought, the concentration of pollution is so high, that the microbiological treatment of the waste water can get disturbed. Use of intermediate technology could help to moderate the quantity of waste water that flows into the cleaning installations.

How does it affect me and my location

Up till now the cleaning of waste water is hardly a problem. Water quality has improved dramatically from 1970, when pollution had turned the rivers into open sewages. For most citizens it is only a matter of money: the pollution tax. In some cases the government takes measures of spatial planning that can affect people, e.g. when agricultural land is claimed to be transformed into an overflow storage.

How long has it been a problem

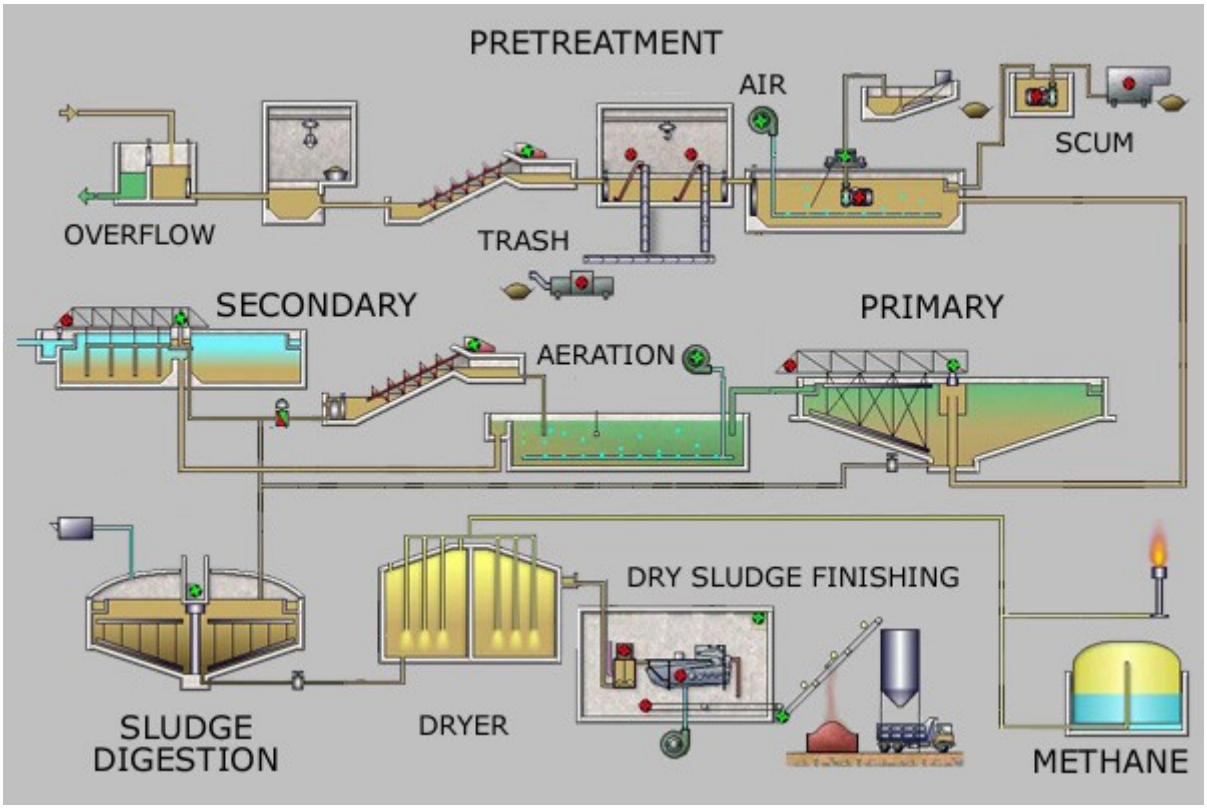
Dealing with polluted water is something of all times. The system of water provision and sanitation began to develop in the 19th century, as a result of cholera epidemics. The cleaning of waste water

developed rapidly since the sixties of the 20th century.

Research on the problem

Cleaning waste water

The cleaning of waste water uses natural mechanisms that are intensified. Water in a natural situation has a capacity to clean itself. Micro organisms break down the pollution. They feed on the organic waste, and they are food themselves for higher life forms. But the self-cleaning capacity of water is limited. That is why water treatment plants are needed. In these installations the natural processes are imitated in an intensified way. In the Netherlands there are about 350 waste water treatment plants. They are called *Rioolwaterzuiveringsinstallatie* (RWZI).



Usually, the RWZI treats the water in three stages:

1. Filtering of solid materials and oily or fat substances (physical treatment).
   By using grids and filters of several kinds, solid objects are separated from the water. The waste water is then pumped into a basin in which heavier solid material deposits on the floor and floating substances, like oil, can be removed.
2. Breaking down organic pollution (microbiological treatment).
   The water coming from the primary purification contains organic and anorganic pollution. Organic pollution is made of any substance that contains a chain of carbon atoms. The most important forms of anorganic pollution are phospate and heavy metals.
   In the secondary purification the water is mixed with a silt that contains micro organisms. These organisms break down the organic material. For this they need a large quantity of oxigen. The capacity of a treatment plant is often measured in the amount of oxigen it uses. Resulting products are mainly CO_2 and NH_3. CO_2 re-enters the atmosphere, and NH_3 is taken to the next step. At the end of this stage the silt deposits on the tank, the water is pumped to

another tank and part of the silt is used to restart the process with new water, while most of it is removed and treated in other ways.

3. Removal of nutrients (microbiological treatment).
   Some substances can be separated from water by means of chemical reactions that result in insoluble salts, but the most important nutrients that have to be removed are soluble. In the tertiary purification the water treatment plant removes NH_3, phosphate and heavy metals.

   NH_3 is transformed in several steps to NO_3^-, again by means of micro organisms. These steps are done in an aerobic environment. The chemical formulas are:
   $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$
   $2NH_4^+ + 3O_2 \leftrightarrow 2NO_2^- + 4H^+ + 2H_2O$
   $2NO_2^- + O_2 \leftrightarrow 2NO_3^-$
   After this, in an anaerobic environment, the nitrate is reduced to N_2 and N_2O, which re-enter the atmosphere. This means that the purification of water has phases in which oxigen is needed, and other phases, in which oxigen should be kept at distance.

   Removal of phosphate is very important for several reasons. Dumping all the phosphate would cause eutrophication, excessive growth of algae and a shortage of oxigen in the water. As can be seen from this process, phosphate is an important fertilizer. Besides, phosphate ore is getting very scarce in the world. Therefore any good way to win back phosphate is economically interesting. In waste water treatment plants three ways are used to remove phosphate. A very simple one is adding iron- or aluminium ions. the very poorly soluble $Fe(III)PO_4$ or $AlPO_4$ can be filtered. A big disadvantage of this process is that it does not result in a form of phosphate that can be used as a fertilizer. Often phosphate is removed by polyphosphate-accumulating organisms (PAO). In an anaerobic tank, the PAO lose all the phosphate they have. Then, when the water is pumped into an aerobic tank, the PAO will accumulate all the phosphate they can get. The sludge that is removed, containing the PAO, is a very rich fertilizer. The third way to remove phosphate is by adding magnesium ions. This will form NH_4MgPO_4, struvite, which can be used as fertilizer.

   New and better methods of phosphate removal usually require expensive adaptations of the treatment plant. Because of the economic value of phosphate alternatives that separate phosphate even before it is dumped into the sewage are researched. One of the methods is the separate collection of urine. Urine is very rich in phosphate, and it is easy to restore the phosphate from the water.

Conclusions on the RWZI

Though the waste water treatment plants are functioning very well, there are several improvements that could be made.

1. The influx of rain water varies a lot and will do so more and more as the climate gets warmer. Peaks in influx disturb the process. Limiting it, by separating rain water from waste water, improves the treatment. Basins are installed to catch peak precipitation, which not only prevent floods, but also peaks in the waste water.
2. A large quantity of pollution of the waste water consists of substances that can be used as fertilizer. Improvements in the treatment are expensive, but can also yield important products.
3. Awareness in the population of the process and of the difficulties can help to prevent people from dumping substances into the sewer that are very difficult to retrieve: grease, paint, etc.

The costs of water treatment are covered by a specific taxation, the *zuiveringsheffing*. A family in Rotterdam will pay € 168,75 per year. In total, in the entire country € 1.255 billion is paid in 2015 for this purpose. With a total population of 16.8 million, this is about € 75,- per person. This figure is only about the treatment as it is. Investments in improving it are not counted.

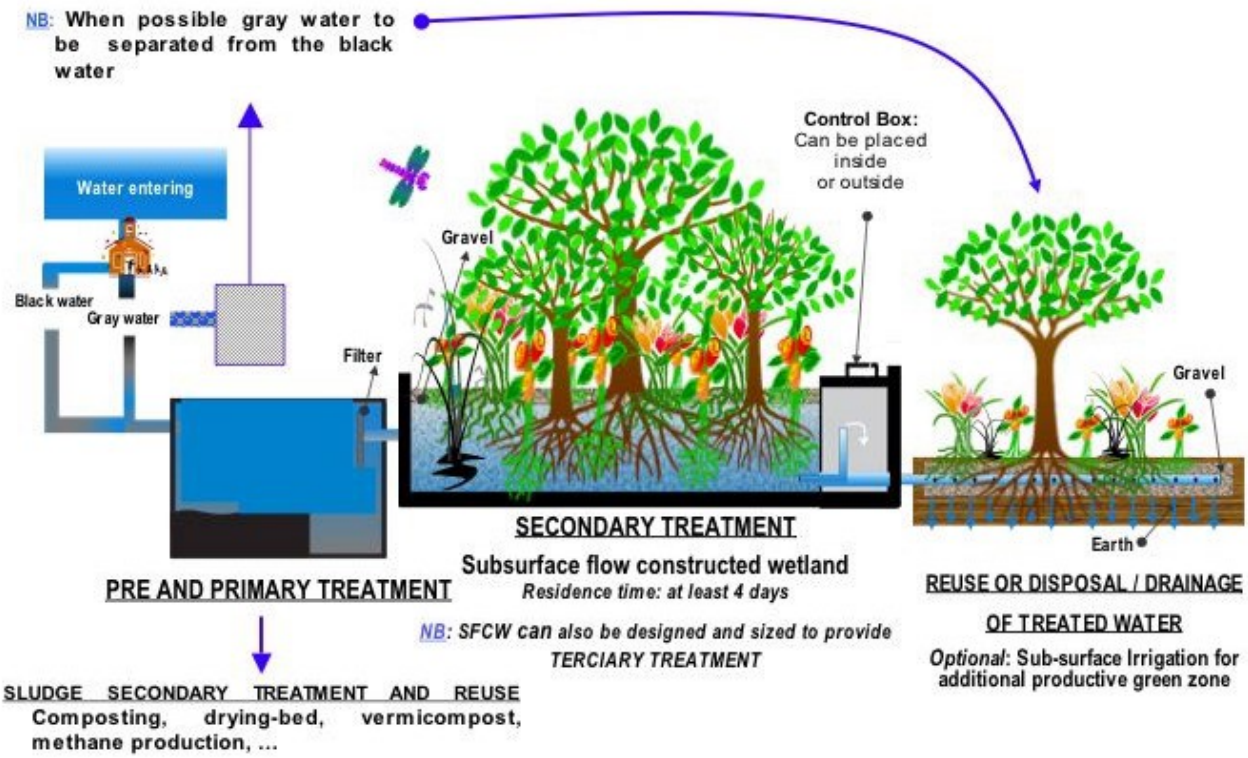
Alternative water treatment by intermediate technology

In some places soft technology solutions are used to deal with waste water. In all stages of the process something can be done.

1. Rain water can be harvested for watering plants and for flushing the toilet. The system can be rather simple: connecting a barrel to the draining pipe, making sure that the barrel will not overflow. A difficulty can be that on flat roofs, sometimes coatings are used that pollute the water. A system that directly uses rainwater for toilets (without having to carry buckets) is rather complex and expensive.
2. Using tap water wisely can save a lot of clean water, and it costs nothing. Awareness about comfortable ways to economise on tap water is what is needed.
3. The sewer is not a waste bin. The system to separate different types of household waste is improving. Substances that everybody used to throw into the sewer, like paint, can now be handed in at a special depot.

Most of these methods take a bit of time and effort, for a very small financial benefit. That is why these methods are not very popular yet. People are a bit easy-going.

A different way of treating waste water could be a small scale alternative for the RWZI. For this purpose constructed wetlands are developed.



A constructed wetland in my neighborhood

A constructed wetland is an artificial wetland, that can be used for waste water treatment and for hosting wildlife at the same time. In my neighborhood, a residential area on the outskirts of Rotterdam, there is some space where a constructed wetland could be made. Space is the main problem, so we shall have to look at the capacity if a constructe wetland might be feasible. For the description of a constructed wetland I used a page of www.en.wikipedia.org (keyword: Constructed wetland.

Subsurface-flow wetlands can be classified as horizontal flow and vertical flow constructed wetlands. Subsurface-flow wetlands move effluent (household wastewater) through a gravel or sand medium on which plants are rooted. In subsurface-flow systems, the effluent may move either horizontally, parallel to the surface, or vertically, from the planted layer down through the substrate and out. Subsurface horizontal-flow wetlands are less hospitable to mosquitoes, (as there is no water exposed to the surface) whose populations can be a problem in surface-flow constructed wetlands. Subsurface-flow systems have the advantage of requiring less land area for water treatment, but are not generally as suitable for wildlife habitat as are surface-flow constructed wetlands. The difference between a horizontal flow system and a vertical flow system is that the vertical flow system is more efficient, but it uses an external energy source. It requires in general 3 m^2 per person.

Too bad for wildlife: for reasons of space, we choose for a vertical flow system. The population of our quarter (Zevenkamp) is 16,800, so we need 5 hectares. This space is available in some hardly used green meadows.

The chemical processes of degrading organic material and removing nitrogen and phosphate from the water are the same as in RWZI. The filtering is done by sand or gravel, the microbiological degradation is done by micro organisms that live on plants in the wetland.

The efficiency of a constructed wetland cannot be controlled as well as in a RWZI. Experiments have shown that sometimes phosphate level is building up, so in the end the wetland would not absorb more phosphate. Plants and sludge that take on phosphate should be harvested to keep the wetland functioning. More research is necessary.

It may be necessary to moderate the quantity of rainwater flowing into the wetland. For this too research and possibly additional measures are needed.

Resources needed

For realising this project in my quarter the following resources are needed:

- Labor: In terms of labor, everything depends on awareness. The project could very well be done by inhabitants, helped by some professionals and experts. If a sufficient number of the inhabitants is convinced of the importance of the project, they could do a lot to realise it: digging, planting, and later harvesting. All this could also be done by hiring people, but the sense of ownership is an important condition for success. If the inhabitants see this project as something of their own, they will be more engaged.
- Money: The more the people do themselves, the less money will be required. If the local government is willing to designate the piece of land for constructing the wetland, no buying of land will be needed.
- Supplies: What is needed, is material for filtering (gravel or sand), plants, pumps, some equipment, some chemicals and some additional microbiological material.
- Technical support: Experts should accompany the construction and also the maintenance and use of the wetland. When functioning, the quality of the effluent water has to be monitored,

in order to keep the wetland in shape.

- Management skills: Not only the construction, but also the functioning of the wetland needs management. This raises the question how much people should be hired on a permanent basis. Probably a trust will be needed to maintain the wetland.
- Time: Probably most of the time will be needed to raise awareness among the population and to convince the local government to cooperate. Building a constructed wetland can be done within a year, but mobilising support, planning, discussing the plans with the local authorities, permit application and so on will probably take at least five years.

Evaluation

Developing an intermediate technology waste water treatment is rather complex. The way water is treated in large scale treatment plants is very efficient and can hardly be matched. The fysical, chemical and biological processes that are used are about the same.

One asset of a constructed wetland could be that it raises awareness about the importance of clean surface water. It may also be part of a larger project to build up a residential area that is recycling all it uses. There are some communities in our country that try to implement that, usually in new-built houses. It is extra challenging to try to convert an existing quarter into one that is cleaning up all the pollution it produces.

Promoting the solution

As can be seen above, promoting the solution is critical for success. In my opinion the construction of wetland as an isolated project will be even more difficult to realise than an even more ambitious plan to realise a "residential area of the future". A solar energy park would also be included in the project, especially because it appers to be difficult to install solar panels on individual houses. A plan that integrates all aspects of sustainability: energy, water, waste recycling will raise more enthusiasm than just dealing with waste water in a slightly different way.

For this project "the residential area of the future" we would need some inhabitants that have some relevant expertise and a nucleus group. This group could try to convince a larger group, and then an awareness raising campaign could start. The local government of Rotterdam organises an annual innovation contest. Participating in the contest at the right moment could add momentum, and make it easier to get the cooperation of the local government. Raising money for the project is also a priority. It should be kept in mind that Zevenkamp has rich and poor inhabitants. The rich can get involved by donating money, engaging the poor inhabitants will be a challenge of its own.

One important asset of the entire plan is the immaterial value it will add to the quarter of Zevenkamp. Built in the beginning of the eighties, it has never been one of the very popular residential areas. Newer areas around it have made it even less popular. Turning it into a futuristic part of Rotterdam could make inhabitants proud of living here.

Literature

- www.wikipedia.nl: key words: rioolwaterzuiveringsinstallatie
- www.watersector.nl
- www.en.wikipedia.org: key words: sewage treatment, constructed wetland
- www.hetkanwel.net