

REED-BED WASTEWATER PURIFICATION SYSTEM FOR AN ECOVILLAGE

ZEGG Ecovillage, Germany

Since 1992, all of ZEGG's wastewater (including blackwater from flush toilets) has been purified by a planted soil filter that uses natural processes and minimal technical effort. The system takes up only 900m² and has the capacity to clean wastewater from 300 inhabitants. This reed-bed wastewater treatment system provides low-cost and low-maintenance biological treatment of domestic or industrial wastewater by filtration, bacterial metabolism, percolation and plant absorption.

Technical description of the purification system

The system can cope with both greywater, such as wastewater from sinks and showers, and blackwater, a.k.a. raw sewage from sources such as flush toilet systems. First, wastewater is pre-treated mechanically in a composter, which works like a big sieve to filter out the solid components of the sewage for compost. The second step is the plant bed, where all the liquids are cleaned by filtering through a planted soil filter. The principle aspect of this technology is the activation of microbial processes that stimulate the natural breakdown of otherwise polluting compounds.



*The system in summer – willows and reeds.
Photo by Mia Saloranta.*

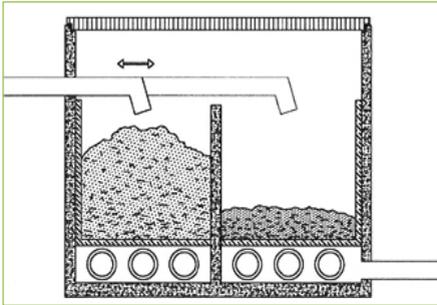
Composter for mechanical pre-treatment

The first step is one of mechanical purification and takes place in a composter. In our case, the composting takes place in a septic tank three meters deep and six meters in diameter; the tank itself has been modified to contain three internal chambers that act like large stainless steel sieves to filter solid matter from the wastewater. This alternative to a traditional septic tank differs from other three-chamber pits in that it does not turn the waste into a faecal sludge. Instead, the solid waste is mechanically separated, then straw or wood chips (in a ratio of 1:10) are added in order to accelerate aeration and the composting process. After about two years, these composted solids may be used as fertilizer, thus closing the nutrient cycle and improving the soil it is applied to. In this way, the nutrients from the solid waste are retained within a cycle of natural elements at a sustainable, local level. (Some nutrients from the next step are retained, too, when the treated wastewater is reused for irrigation.)

Functioning principles of the plant bed

In the second step, the pre-treated wastewater from the septic tank is channelled into a collection tank. From there it is pumped to the surface of the reed beds by a single pump operating for 10-minute periods several times a day. On the surface it spreads out along the filter beds, which are divided in half in order to facilitate bi-monthly alternation between active and resting portions of the beds.

Purification takes place in a vertical planted-soil filter. It is about 1.2 m deep and filled with coarse, washed sand containing iron flakes, which remove phosphates. The inflow at the top of the system is aerobic. Drainage pipes at the bottom lead a portion of the outflow back to the duct, where it joins the new inflow and is pumped through the system again. Though soil filters generally require an area of 3m² per person, this feature increases the purification performance



Black water enters on top, solids are filtered out and wastewater then runs off through the bottom.
Drawing by Dirk Fiedler.

of the system and has reduced this requirement to only 2m² per person. During the entire process, the wastewater remains oxygen-rich (4-6mg/lO₂). This aerobic environment enhances the cleaning power of the plant and ensures nearly odourless functioning.

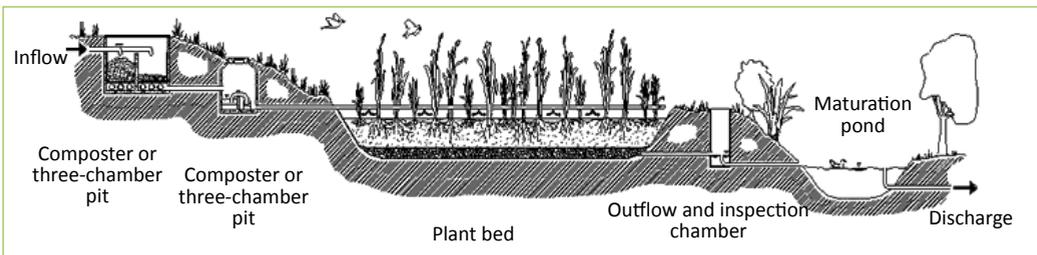
The sand filters out solid particles, some remain on top, forming a humus layer. Smaller particles are broken down among the grains of sand, which provide a surface for the growth of the micro-organisms who do all the decomposition work. Almost all the ammonium in the wastewater is transformed into nitrate by an effective distribution of the water, removing odours and guaranteeing an optimal oxygen supply for the decomposing micro-organisms and a vertical flow through the body of the filter.

Some of the organic nutrients removed from the wastewater in the planted beds are taken up by the plants and become biomass; the rest are broken down into gases by the micro-organisms. These extract oxygen from the nitrates in order to break down the organic substances in the fresh wastewater, thereby producing atmospheric nitrogen which is released into the air. The plant bed is also dammed, increasing the retention time and making it possible to break down difficult compounds. With an extra de-nitrification pond, the nitrogen concentration in the effluent could be stabilised and reduced as low as 13 mg/litre or even less. In the humus layer that builds up on top of the system, persistent substances are adsorbed and decomposed through ultraviolet radiation and further micro-organisms.

A range of different plants grow in the sand of these reed beds. In turn, these provide shade for the filter surface so it does not bake hard in the sun and dry out or close up due to the growth of algae. The plants' root excretions also stabilize the micro-flora. In the treatment plant at ZEGG, we have mainly used plants that produce a lot of biomass and can be harvested regularly, such as Japanese silver grass or Eulalia (*Miscanthus sinensis*), a local type of common reed (*Phragmites pseudodonax*), and a local type of willow (*Salix viminalis* "Mötzow"). Every one to two years we cut the willows, which helps keep the roots small so they will not grow through the clay sealing. The biomass of these cuttings can be used for mulching, composting, or as wooden biomass for wood-fired burners.

After professional planning and layout of the system, construction and installation work can be done by many unskilled labourers, as long as they are supervised by an expert. The main labour consists of setting the clay sealing into place, spreading the sand, and planting. We used clay which was compacted into a 20-cm thick layer to seal the system; alternatively, rubber EPDM sheeting makes a good liner. The maintenance, material, and energy involved in creating such a system are all quite low.

The outflowing water quality is tested at regular intervals, and we have discovered that a very high quality of outflow is achieved throughout the year, even during the coldest period when temperatures fall below -15°C for more than a month. The system reduces concentrations



Wastewater runs in on left through the composter, is pumped onto the surface of the reed bed, and runs out at the bottom to a pond where it seeps back into the groundwater or to a stream.
Source: www.bio-system.de.

of pollutants to levels consistently below German statutory limits. In short, the unit at ZEGG is a model for small communities and for households which are outside of towns and off the grid. It exemplifies the regenerative powers of nature by harnessing them in a wastewater purification process. Beyond this, the system also enriches and beautifies the environment by adding a wetland biotope, offering valuable living space to many species of plants and animals.



*During harvest of willows.
Photo by Achim Ecker.*

An essential ecological value: Sustainable water management

It is our goal to develop ecologically sound ways of dealing with water resources, by understanding both regional and global issues, thereby providing future generations with a solid foundation strongly based on a sense of personal responsibility for those resources.

A prerequisite for regional water management is to have access to technologies that, among other things:

- can also be used on a small scale;
- are inexpensive;
- have a high yield;
- tolerate load fluctuations;
- can produce hygienic, recycled water;
- require hardly any energy;
- enrich the landscape.

The efficiency of soil filter technology has already been proven and we are continuously improving it through various research programs. The risks inherent in central wastewater disposal are also largely avoided, since:

- no further waste water transportation is needed;
- the use of resources is reduced;
- the burden on groundwater is reduced;
- rainfall is retained in the area, which is valuable in areas with low precipitation ;
- consumer awareness around water is promoted;
- the outflow can be used for irrigation.

User experiences

Users of the system usually do not even notice the reed beds, and beyond the additional request that inhabitants utilize biodegradable soaps, its use imposes no requirements other than those for any normal wastewater cleaning process. In addition, people are proud to live in a community that utilizes a clean and efficient natural cycle to purify water.



*Wastewater purification plant after harvesting the willow wood.
Photo by Achim Ecker.*

We chose this solution because we had used reed bed systems before on previous sites, and also because it was both an obligation in the sales contract for the land and one of the founding premises of ZEGG to build our own system (at the time of purchase in 1991, there was no central solution available from the municipality). We have come to love a system that makes us feel closer to nature and gives us a sense of responsibility for our own “waste”. This natural closed cycle is a very visible demonstration that one person’s

trash is another's treasure, or that each organic by-product is another organism's resource: as they say, "shit makes flowers grow" and this can be directly observed in a system where there is no waste.

We have always been proud of this system, and we do not want to lose it. Unfortunately, European and German legislation have made it difficult or nearly impossible for individuals to make their own decisions concerning both water supply coming in and wastewater going out of their property. ZEGG is currently under pressure from the local municipality, who wishes to force us to connect to the public grids, and against which we have no legal recourse. It seems that sooner rather than later we will be forcefully connected to the public grid. Though we will be able to continue to operate the plant-based system, the purified water will then have to flow into the public sewage pipe. Most bitter of all, we will lose the right to draw our drinking water from our own wells. We therefore recommend that you check your local legislation regarding water rights and usage before embarking on your ecological wastewater project.

Author: Achim Ecker

Further information

· Dirk Fiedler, e-mail: dirkfiedler@web.de

· www.oekotec-gmbh.com/download_en/frames/index.htm; www.blumberg-engineers.com/;
www.constructedwetlands.net/index.html

· In German: www.dwornitzak.de/Kurzbauleitung.pdf; www.naturbauhof.de/lad_pka_funktion.php;
www.baufachinformation.de/artikel.jsp?v=223825

NATURAL BIOLOGICAL WASTE WATER PURIFICATION SYSTEM FOR ONE HOUSEHOLD

Ecovillage "L.A.S." (Local Alternative Society), Poland



*Building a natural waste water purification system.
Photo by Monika Podsiadła.*

Finding a solution to the problem of waste water treatment is among the top priorities of a sustainable lifestyle: how can we recirculate the used water back into nature's cycles as good clean water. Root waste water treatment is introduced here as an effective and cheap technology that can even be built utilising recycled materials. A purification plant such as this may finish with a pond and the water can flow from the pond straight into the meadow, garden or back into a household's water system (e.g. as flushing water for the toilet). Utilising natural waste water treatment systems like this could enable ecovillages and village societies to abandon expensive concrete cesspits, which often poison the subterranean water and natural surroundings of the settlements – gardens, meadows, and farmland. Similarly, commercial biological, bacterial filters and water purification plants are often expensive and require the use of heavy machinery.

Technical description

Basically, this waste water treatment consists of two tanks, each 1m³ (1000 litre) and protected by a steel grate. This capacity can purify grey and black water for a family of three. These recyclable tanks can be bought in larger petrol stations and should be carefully cleaned inside before use.