

## We conclude that...

...**sand is a better bed material** than gravel for cleaning wastewater. Since the grains are smaller, pollutants are filtered better, and the total grain surface area is larger – therefore the area where air is brought into the wastewater is larger, which gives more oxygen to the working bacteria. But care needs to be taken so that the sand grains are not *too* small – this can cause the bed material to clog.

...**more nitrogen is removed with plants** than without them. This can be an effect of the roots taking up nitrogen, and also releasing oxygen and sugar which makes the nitrogen-removing bacteria more active. The benefit of plants might not be large, but since they can help it can be good to have them.

...**applying wastewater more often in smaller doses** gives a more efficient cleaning. A smaller dose flows more slowly through the wetland and gives more time for the microorganisms to remove pollutants. Although care needs to be taken so that doses are not applied *too* often – the wetland needs to rest after each dose to refill the pores with oxygen for the working microorganisms.



Contact:  
Linda Olsson  
olsson.lin@gmail.com

## Cleaning wastewater with sand, bacteria and plants

- How to design the treatment solution of the future?



Linda Olsson  
Ecology and the Environment 2011  
Supervisor: Tom Headley



## Onsite wastewater treatment

As the human population grows larger, so does the need of finding more efficient ways of taking care of our waste products. Wastewater contains a lot of pollutants like organic material, nutrients and bacteria, and releasing it into a water body can cause severe problems such as algal blooms and spreading of diseases.

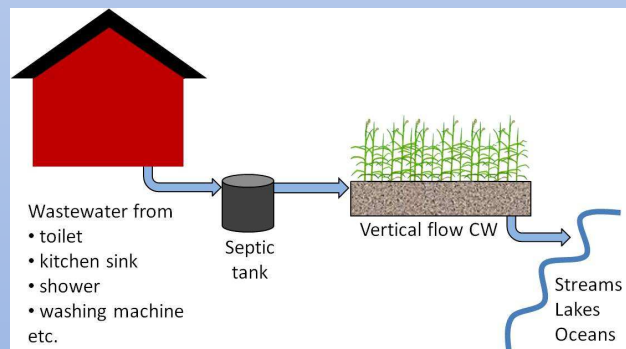


Photo: Anna Senior

Cleaning wastewater at the same place as it is generated (onsite) is in many ways the most efficient solution, and in rural areas it is a necessity. The only question is: *how?*

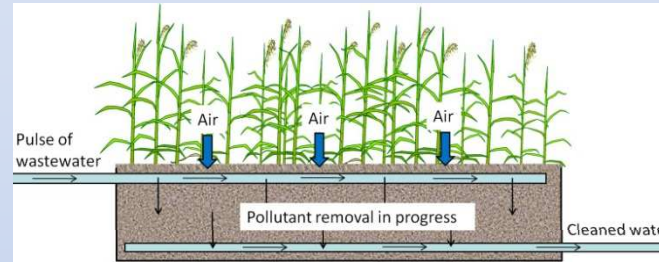
## Vertical flow constructed wetlands

In **vertical flow constructed wetlands** (VF CWs), pollutants are removed from wastewater by the natural interactions of microorganisms, plants and a sand or gravel material. The wastewater is pre-treated in a septic tank and then further cleaned in the VF CW, before being released into water bodies.



Onsite wastewater treatment with a VF CW.  
(Courtesy of Tom Headley for the plants in this diagram.)

In the cleaning process, wastewater is applied in pulses on a sand or gravel bed, and pollutants are removed as the wastewater moves downward by gravity. This movement creates a suction that draws air into the pores – this helps the bacteria that remove pollutants to breathe and work better.



Flow of water and air in a VF CW for wastewater treatment.  
(Courtesy of Tom Headley for the plants in this diagram.)

## How are pollutants removed?

**Organic material** is eaten by microorganisms living in the bed, or filtered away by the sand or gravel.

**Nitrogen** (a nutrient) is mainly removed by specialized bacteria that use it instead of oxygen for breathing. Nitrogen is also used by bacteria and plants as building blocks for their own growth, but it is still unknown how important plants are for the total removal of nitrogen in VF CWs.

**Bacteria** from human intestines (such as *Escherichia coli*) are filtered away or eaten by other microorganisms in the bed.

## The aim of this study

What we still do not know is how VF CWs should be designed and operated to remove as much pollutants as possible. We wanted to find this out, by answering these questions:

- 1) Is **sand or gravel** a better bed material?
- 2) Do **plants** (reed) improve pollutant removal?
- 3) Should the wastewater be **applied** more often in smaller doses or less often in larger doses?

## Experiments

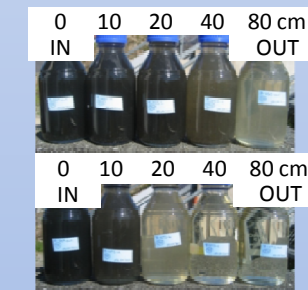
We carried out the study at a test facility in the village Langenreichenbach outside Leipzig in Germany. Wastewater from households in the village was cleaned in 6 VF CWs, all designed and operated in different ways.



We took wastewater samples at 5 different depths during 5 months from each VF CW and compared the content of pollutants after laboratory analyses.

## What did we find?

- 1) More pollutants were removed in wetland beds with **sand** compared to those with gravel.



← This water was cleaned in a **gravel** bed wetland - it is still quite dirty when it comes out.

← This water was cleaned in a **sand** bed wetland - it is much cleaner!

- 2) Wetlands **with plants** sometimes, but not always, removed more nitrogen than those without plants. The plants did not affect the removal of organic material and bacteria.

- 3) When wastewater was **applied more often in smaller doses**, more pollutants were removed in the upper part of the wetland – this means more efficient removal.