Treatment wetlands in Austria: Practical experiences in planning, construction and maintenance

This paper presents information on practical experiences with constructed wetland systems in Austria.

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Abstract

In this paper we report our experience regarding design, operation and maintenance of constructed wetlands (CWs) for treating domestic wastewater in Austria. About 1600 vertical flow (VF) CWs have been constructed by our company Ökologisches Projekt Ltd (ÖP ltd) during the last 20 years. The company also provides operation and maintenance services for owners of CWs and carries out the yearly monitoring for about 750 systems. Based on these experiences we present our considerations and recommendations concerning the operation of constructed wetlands.

Introduction

2008 in Austria about 93 % of the wastewater is collected in central sewers and biologically treated. For the remaining small rural settlements and single households decentralised small scale biological treatment is more feasible for economic and ecologic reasons. In the beginning of the 1980's the first horizontal flow constructed wetlands went into operation in Styria. Since the 1990's vertical flow constructed wetlands are favoured because also small scale treatment plants have to fulfil nitrification according Austrian effluent standards (1.AEVkA, 1996). The effluent standards for plants <500 PE are:

COD:	90 mg/L
BOD_5:	25 mg/L
NH_4-N:	10 mg/L (T>12° C)

Meanwhile some thousand CWs are in operation (the estimated number is between 3000 and 4000), most of them in the province Styria. The most common application for CW systems is treatment of domestic wastewater. Additionally, reed beds are used to dewater and stabilize excess sludge from technical plants and sludge from primary pre-treatments.

To reach a steady treatment efficiency operators have to observe some operation and maintenance measures. The water authority prescribes a regular monitoring by the operator plus a yearly report of an external professional which has to prove the observance of the effluent standards.

CW System description – *Type Ökologisches Projekt*

Figure 1 shows a sketch of the system components of the CW system *„Type Ökologisches Projekt"*. The system comprises a mechanical pre-treatment, an intermittent tank and the VF filter bed. In the following a description of the technical components is given:

Key factors:

- In Austria constructed wetlands have developed from an alternative solution to a conventional and well accepted technology for wastewater treatment in rural areas.
- The typical Austrian CW system comprises mechanical pre-treatment, an intermittent tank for storing the wastewater for the intermittent loading and a VF filter bed.
- According to the Austrian design standard the VF filter bed is designed with a specific surface area of 4 m² per people equivalent.
- With this design the stringent Austrian effluent requirement regarding nitrification can be met.
- Regular checks by the plant operators plus a yearly external plant inspection within a maintenance contract help to detect or rather prevent malfunctions of the CW system.

1. Mechanical pre-treatment

Usually a 3 chamber septic tank is used which has a minimum volume of 3 m³ and minimum volume of 0.3 m³ per person equivalent (PE).

2. Intermittent feeding system

Through intermittent feeding the pre-treated wastewater is loaded to the VF filter area intermittently. The wastewater is distributed on the whole surface through perforated pipes.

Depending on the terrain there are different options for loading the beds: the presence of a difference in height between the pre treated wastewater and the filter bed allows the utilization of mechanical devices without using electric, fossil or solar energy. Usually a quantity related feeding by a float switched pump or by energy free valve is applied.

The valve works according to the principles of buoyancy respectively repression. E.g., Type RV 250 delivers 250 litres per minute; RV 500 delivers 500 litres per minute. 84 % of the ÖP systems are equipped with the valve, 15 % of the intermittent loading systems are using pumps, and 1 % of the plants are equipped with tipping buckets.

3. Vertical flow filter bed

The VF filter bed has an average area of 4-6 m²/PE, an overall depth of 0.9 to 1.1 m and 1 % slope at the bottom. It is sealed with HDPE foil. The filter media used in a VF bed from bottom to top are:

- 20-40 cm gravel 4-8 mm
- 50-60 mm washed sand 0.06-4 or 1-4 mm (d_{10}>0,17 mm)
- 20-40 mm gravel 4-8 cm

Crosswise pipes with DN 100 and longitudinal with DN 25 or DN 50 are laid on concrete bricks in order to have open space between gravel surface and distribution pipes. An even distribution of the wastewater on the whole surface has to be achieved.

The efficiency of the loading is dependent on the cross section of the pipes, the distance of pipes, the distance of holes and the feeding quantity per interval. The feeding system should be situated above the surface to be accessible for maintenance works.

A control shaft is situated at the longitudinal end of the filter bed so that the water level can be adjusted by a flexible pipe. The height of the water level in the VF is about 10 cm.

The filter beds are planted mainly with common reed (*Phragmites australis*).

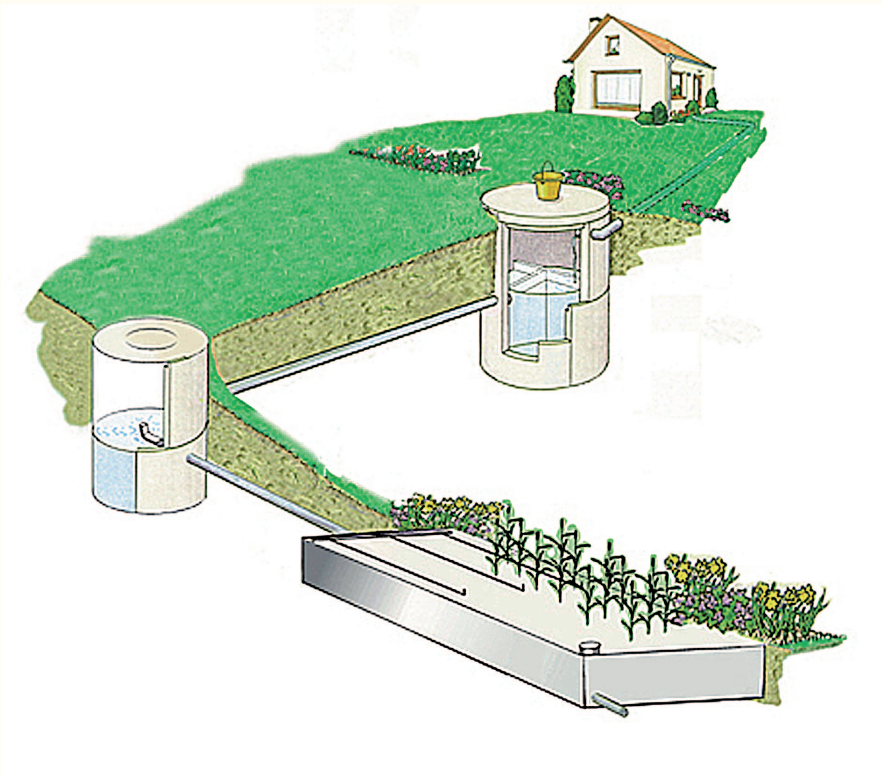

Figure 1. Schematic sketch of the system components of a CW system *„Type Ökologisches Projekt"*

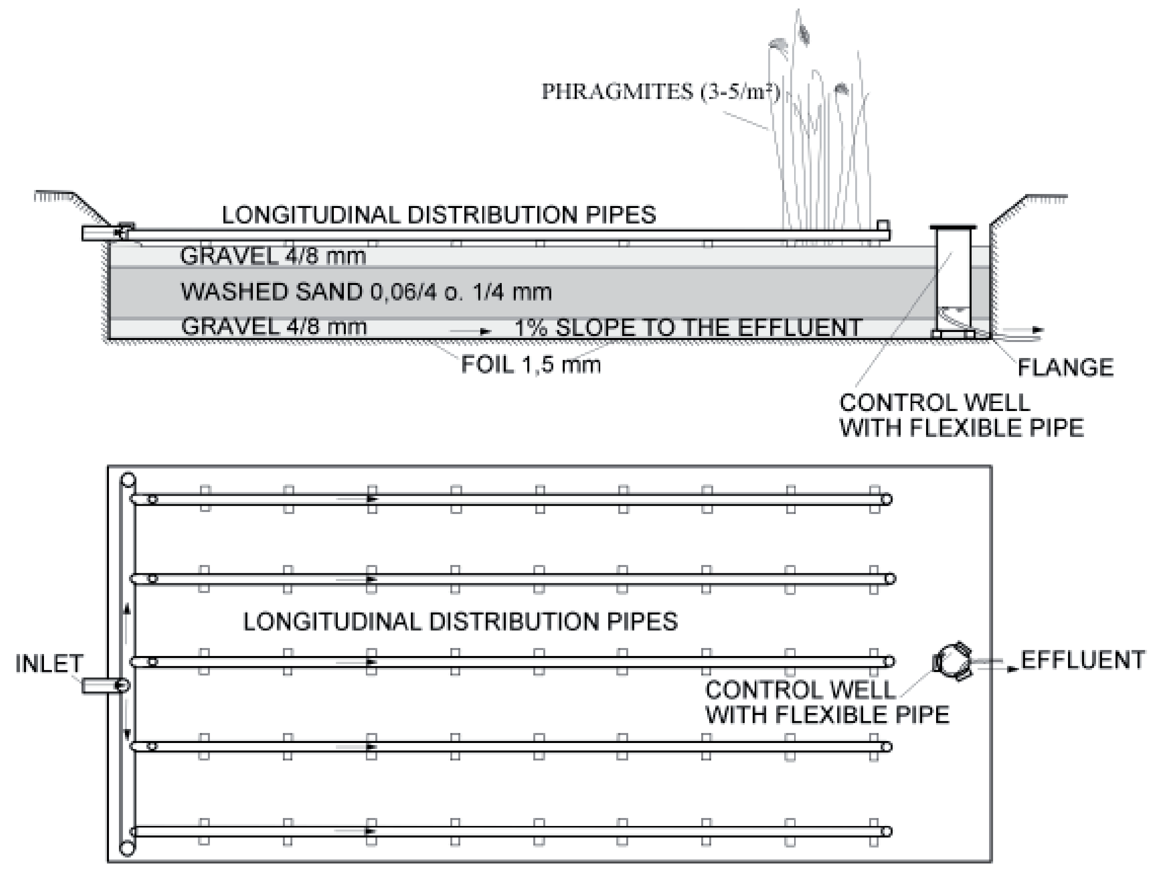

Figure 2. Sketch of the VF filter of the CW system *„Type Ökologisches Projekt“*

Table 1 gives an overview on the number of these systems designed and constructed by the company during the last 20 years. In total about 1600 CW systems have been constructed.

Table 1: Number of CW systems constructed

Person equivalents (PE)		
from	to	number of plants
-	4	2 19
5	10	784
11	12	295
13	20	158
21	40	80
41	50	28
51	100	14
101	800	5*)
Total		**1578**

*) combinations of technical treatment plant and CWs

Treatment effciency

To illustrate the treatment efficiency the effluent analyses made in the year 2011 within maintenance contracts are ranked in categories according to the NH_4-N concentration (Table 2).

Table 2: NH_4-N effluent concentrations in 847 samples of 2011

NH_4-N (mg/L)				
Category	from	to	n	%
1	0	1	596	70
2	1	10	172	20
3	10	20	50	6
4	20	30	14	2
5	30	40	7	1
6	>40		8	1
Total number of samples:			**847**	**100**

The first two categories (90 % in total) are within the limit of the effluent standard of 10 mg NH_4-N/L, 70 % are even below 1 mg NH_4-N/L. 302 samples were taken at wastewater effluent temperatures <12°C showing that nitrification effluent requirement can be fulfilled with VF CWs also at lower temperatures. The figures show that the applied design and construction are appropriate for the treatment of domestic wastewater. The analysed plants are between 1 and 20 years old. At the beginning of this period in 1991 a specific surface area of 6 m² filter area per PE has been used for designing the VF beds, later 4.5 -5 m²/PE. According to the new Austrian design guidelines for CWs (ÖNORM B 2505, 2009) 4 m²/PE is state-of-the-art. Compared to the design guidelines of other countries the sizing of the Austrian type is rather big but requested to guarantee safe operation of the systems during the winter months. This explains why they are robust and show good treatment efficiency also during cold temperatures.

Problems and difficulties in design, planning, construction and maintenance

In the following chapter the most common problems and difficulties in design, planning, construction and maintenance are listed:

Design, Planning

Lack of data for water quantity and load

The dimensioning based only on the number of persons often is not feasible in practice. Some households are not equipped with water meters, especially when they derive the water from their private water well. There is lack of real quantities and loads which leads to over- or under dimensioned treatment plants. This is why a certain effort should be taken over to gain realistic figures. It has shown that there is a broad range in the concentration of domestic wastewater (Table 3).

Construction

Deficient retention of surface water - superficial runoff

Soil substrate from surroundings is washed in the filter and causes clogging of the gravel and sand layers. To prevent this border strips should be established around the filter beds.

Unsuitable filter media

For economical and ecological reasons it will be intended to derive sand and gravel from near as possible to the building object; when new providers are introduced the grain size of the sand should be tested. Until now problems have aroused through the use of too fine sands which led to clogging of the filter.

Uneven building of the slope of the sand layers

Poundage of water in single areas of the filter bed might lead to soil clogging.

Intermittent feeding system not adjusted for filter area

No even distribution above the filter leads to water logging, in succession soil clogging might occur.

Displacement of distribution pipes

See point above

Table 3. Inlet concentrations according Austrian design guidelines and analyses made by ÖP ltd. in 2011 (in mg/L)

Parameter	ÖNORM B 2505 (2009)	Analyses by ÖP ltd., n=71		
		Mean value	Min	Max
CSB	-	663	326	2607
NH_4-N	66	88,9	58,1	339

Different additional treatment requirements in different Austrian federal states

Within the 9 Austrian federal states and even within the districts in a federal state different requirements for the effluent quality can be set by the authorities, e.g. the infiltration of effluent wastewater in the ground or the agricultural utilization of sludge of the pre-treatment is allowed in one and forbidden in another province. Additionally, the elimination of phosphorus can be prescribed in one province and not necessary in the other.

Special applications of CWs

In Austria there is still lack of practical experiences for treatment other types than domestic wastewater like in the treatment of milk chamber wastewater, slaughtering wastewater or seepage sewage from the composting process.

Mechanical pre-treatment using a septic tank

Missing dip tubes cause poor detention storage of solid matter.

Poor quality of concrete parts of septic tank and intermittent feeding well causes corrosion and hence sludge drift from three chamber septic tank.

In some cases efflorescence occurs in the concrete wells. If there is not enough aeration through the house, the covers of the concrete wells should be perforated or ventilation of the gases from the wells should be achieved by other means.

Operation and maintenance requirements

It should be aim of a professional service for CWs to detect problems before they become visible in a reduction of treatment efficiency. It is a characteristic of CWs that mistakes in operation are buffered over a long time. In the case of long term these malfunctions might lead to soil clogging. When it is evident in reduced treatment efficiency it can take a long time until they are completely restored.

The plant owners are instructed about the necessary maintenance works and obliged to keep a "maintenance book" documenting weekly or monthly controls of nitrification with a test kit. They also should check the condition of the three chamber septic tank, the intermittent feeding system and the even distribution through the pipe system in regular intervals.

Pre treatment

The sludge of the pre-treatment has to be emptied in time in order to prevent sludge drift into the reed beds. The emptying intervals depend on the size of the pre-treatment system and vary between one year and several years. The sludge can be stabilized in a separate sludge drying reed bed on the spot. Alternatively it can be transported to a central sewer plant for further treatment.

Intermittent feeding system

The functioning of the intermittent feeding by the valve can be checked by measuring the difference in height in the well before and after the feeding process. After some years the rubber part of the flexible pipe can be porous which is why the wastewater seeps continuously only into the front part of the filter bed. If this is not detected the filter will be clogged after some time. This is why the device should be controlled once a month.

Filter bed

During the first year attention should be paid to the growing of the plants. Weeds should be removed until the reed is established.

An uneven distribution of wastewater above the filter is the most common problem of malfunctioning of constructed wetlands. It can be measured by collecting the water flowing out the pipes at the 4 corner points of the filter bed. The distribution system can be best adjusted and cleaned after the cutting of the plants.

The cutting of the plants can be made in spring. Some operators prefer to cut the reed in autumn, lay the dry straw on the filter surface and remove it in spring because then there are less small leave parts on the filter surface. The water level in the filter bed should be as low as possible.

Conclusion

Constructed wetlands have developed from an "alternative green idea" to a conventional and well accepted technology for wastewater treatment in rural areas of Austria.

To keep a high treatment efficiency and steady operation the operators have to observe some maintenance works and regular controls of the system components.

A regular external examination by a professional helps to detect problems and recommendations can be given to the operators. Finally the long term operation is also documented in a "plant history" by the company.

References

1.AEVkA (1996): 1. Abwasseremissionsverordnung für kommunales Abwasser (Austrian regulation for emissions from domestic wastewater). BGBl.210/1996, Vienna, Austria [in German].

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