Sanitation system for the 'Gloggnitzer Huette' mountain refuge

This paper gives information about the feasibility of source separating sanitation solutions for mountain refuges.

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Abstract

The sanitation system of a small mountain refuge situated in a sensitive drinking water catchment had to be adapted to reach appropriate wastewater treatment and disposal. As the refuge is dependent on hand-carried drinking water and photovoltaic energy supplies the energy and water demand of a new system had to be as low as possible. A combination of a composting toilet, waterless urinals and a constructed wetland was foreseen to meet these requirements. Since the mountain refuge is opened at weekends only, peak loads have to be expected. A buffer tank was installed for flow equalisation and greywater storage during winter. With the help of a volume-controlled inflow pump, the greywater inflow can be distributed over a whole week preventing dry-out of the constructed wetland. The effluent of the constructed wetland is discharged in an evaporation bed. To increase the degradation of organic solids in the composting toilet, a solar heat collector is used for ventilation of the composting chamber. The system start up was in spring 2011. It will be intensively monitored and shall serve as pilot for other mountain refuges under comparable conditions.

Introduction

More than 15,000 public and private mountain refuges can be found in the Alps (Grinzinger, 1999). Due to their remote location the infrastructure of mountain refuges are mostly stand-alone systems. An integrated management of energy and water supply, wastewater treatment and waste disposal is needed. Technical support, training, user friendly control and simple system set up are preconditions for a reliable operation of the infrastructure (Weissenbacher et al., 2008). A number of mountain refuges are situated in the catchment area of Vienna's drinking water supply. The hydrogeology is sensitive and therefore the Vienna Waterworks and the water authority demand safe wastewater treatment from objects within the water protection areas to avoid adverse impacts on the drinking water quality.

One of these objects is the Gloggnitzer Huette (GH), see Figure 1. This private refuge was without appropriate wastewater treatment and therefore subject to adaptation during the overall renovation in 2010. The goal of the adaptation of the sanitation system was to treat the produced wastewater to the state of the art under the difficult operation conditions of the refuge. Beside that the water supply should be improved by rainwater use. The main challenges of the project were the wastewater load variations due to the weekend operation as well as the limited energy availability. Due to the fact that the building is not accessible via road transport, helicopter transport was necessary. The Vienna waterworks were closely involved in planning and construction. The aim of this paper is to describe the developed solution to under the specific conditions of the GH.

Technical data:

- Toilet waste treated in composting toilet
- Wastewater produced (greywater, urine and leachate from composting toilets): 110 L/day
- Design load for wastewater treatment plant: 4 person equivalent (p.e.)
- Buffer tank (1 m³) with to equalize flow
- Vertical flow constructed wetland for greywater and urine treatment with 1.25 m² per p.e.
- Final effluent from constructed wetland discharged in evaporation bed (ca. 4 m²)

Figure 1: Overview on the catchment of Vienna Waterworks and the site of the 'Gloggnitzer Huette' (Source: www.wasserwerk.at). Shaded areas mark zones of water protection. Blue lines are the water supply mains of Vienna.

Boundary conditions and basic concept

The mountain refuge 'Gloggnitzer Huette' is located on the mountain 'Raxalpe' in Lower Austria at an altitude of 1548 m. It can exclusively be reached by foot and is opened for guests at weekends in summer and at selected weekends in winter. The capacity is for 22 overnight guests. Up to now, the refuge was equipped with a pit latrine. There is no water supply connection; the water used in the refuge has to be carried by hand from a nearby spring. Power was supplied by photovoltaic panel and battery storage. The whole system is powered in DC mode.

To account for the load variations and the limited power and water availability, a low energy biological wastewater treatment with sufficient buffering capacity and toilet facilities with low water consumption were necessary. It was decided to use a combination of a composting toilet and greywater treatment by vertical flow constructed wetland followed by an evaporation basin. Rainwater harvesting should provide an additional water source.

Legal requirements

Table 1 compares the permits of the 'Gloggnitzer Huette' to other relevant Austrian legal ordinances. Within the legal procedure the requirements for the treated wastewater have been reduced to BOD5 of 15 mg/L and NH4-N of 7 mg/L for the protection of the drinking water catchment in the area. These requirements have been stated by the water authority prior to the detailed technical design of the system. As the refuge is located in the sensitive drinking water catchment permits for Enterococci and E.Coli have been added to the standard parameter set according to the minimum hygienic requirements of the Directive 2007/7/EC (Bathing Water Directive).

Wastewater production

Due to the fact that there is no piped water connection, the water use could not be monitored as foreseen by planning guidelines (OEWAV Regelblatt 1, 2000) or the wastewater emission directive for remote stand-alone buildings (3.AEVkA, 2006). Hence, the wastewater production had to be estimated. Wastewater, i.e. greywater, is generated mainly in the kitchen and the washing room of the refuge. Smaller amounts originate from the waterless urinal and the leakage of the composting toilet. The weekly amounts were estimated based on the operator information as follows:

Under the assumption of operation of the refuge for 40 weekends and 5 public holidays the figures in Table 2 result in a total wastewater volume of 5 m3 per year. It is assumed that the same amount of wastewater is produced on public holidays and weekends. Including a safety margin, a design load of 4 p.e. (as 60 g BOD5/p.e./d) and an average wastewater design volume of 25 litres per day have been selected (175 L/week).

Table 2: Estimation of average wastewater production for weekends and public holidays.

Guests	Wastewater per unit		Total per weekend
6 Overnight	10	L/day	60 L
10 Daytime	5	L/day	50 L
			110L

Table 1: Requirements regarding the urban wastewater treatment directive (1.AEVkA, 1996), the directive for stand-alone buildings in remote areas (3.AEVkA, 2006) and the specific permits for the 'Gloggnitzer Huette'

Parameter	1.AEVkA (1996)	3.AEVkA (2006)	GH Permit (2010)
NH4-N*	10 mg/L	0.9 g/p.e./d	7 mg/L
BOD_5	25 mg/L	12 g/p.e./d	15 mg/L
COD	90 mg/L	36 g/p.e./d	60 mg/L
Enterococci	-	-	330 MPN/100 mL
E.Coli	-	-	900 MPN/ 100 mL

MPN … most probable number (a method for estimating counts of microorganisms)
p.e. … person equivalent
*at wastewater temperatures: >12 °C

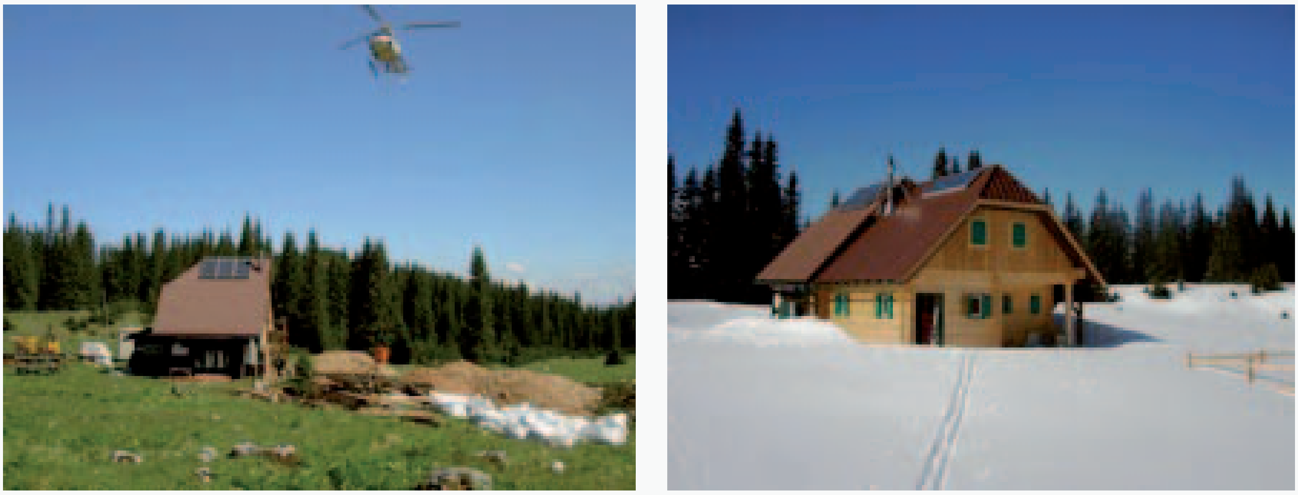

Figure 2: The 'Gloggnitzer Huette' at an early stage of adaptation and renovation - helicopter transport of construction materials in progress (left) - and after the renovation in winter (right).

System design

To reduce the wastewater quantity and solid load a composting toilet is used. This toilet assures that the largest part of organic matter and a significant amount of nutrients is retained away from the wastewater stream. The faeces are stabilized aerobically in the toilet chamber. After a secondary rotting process in composting bags, the compost can be easily transported for disposal to the valley.

There are two toilet seats connected to the composting chamber. Pre-heated air (solar collector at the roof) is piped to the basement where the composting chamber and the buffer tank are situated. Two vents blow the exhaust air from the urinal and the composting chamber to the outside of the building (Figure 3).

Greywater from the kitchen and the washing room as well as wastewater from the waterless urinal and leachate from the composting toilet are collected in a buffer tank of 1 m^3. At the inlet of the tank a filter is installed as a pre-treatment to remove solids (Figure 4). Since the wastewater production varies significantly during the week and the year, the tank is used as a flow equalisation to the wastewater treatment plant.

Figure 3: Scheme of the composting toilet and the ventilation (left) and composting chamber (right).

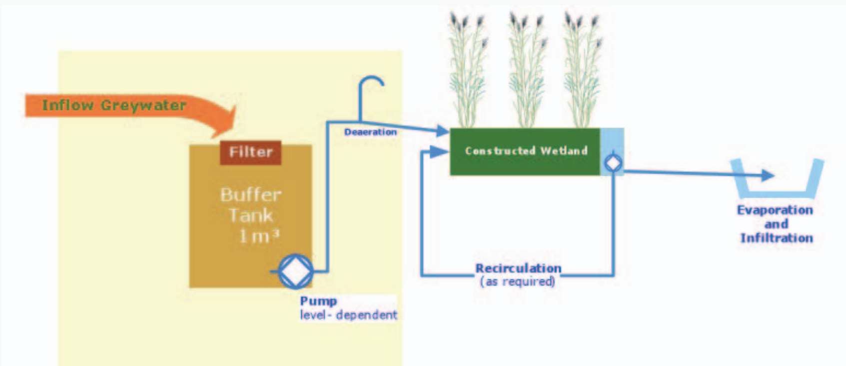

Figure 4: Scheme of the greywater and urine treatment.

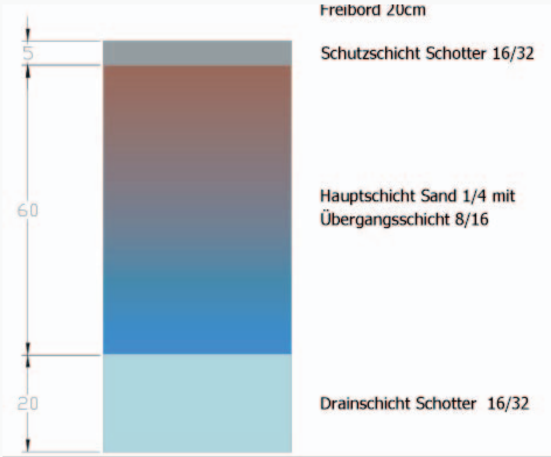

Figure 5: Vertical flow constructed wetland (left) and the layers of the vertical flow bed (right).

Due the effluent ammonia requirements stable nitrification is necessary. Therefore, a vertical flow constructed wetland was selected to treat the greywater from the kitchen and the washrooms, the urine from the dry urinal and eventually occurring leachate from the compost chamber. Normally the Austrian design guidelines foresee 4 m2 of surface area per p.e. for vertical flow constructed wetlands (ON B 2505, 2009). In the case of greywater/urine treatment only, 5 m2 surface area of the vertical flow bed for the estimated average load of 4 p.e. have been considered as sufficient. Overdesign could lead to dry-out and induces unnecessary costly transport by helicopter. The low energy demand and the ability to cope with load variations of constructed wetlands are further advantages of the constructed wetland for this particular application. The constructed wetland and the layers of the gravel filter are shown in Figure 5.

As stated above, the buffer tank prevents load peaks and the distribution of the inflow during non-operating periods (weekdays). The constructed wetland would be otherwise being prone to dry out. The wastewater from the buffer tank is pumped in batches to the treatment depending on the water level to ensure a distributed inflow to the constructed wetland. The volume of the inflow batches decreases with decreasing actual volume of greywater in the buffer tank.

The effluent of the constructed wetland can either be re-circulated to the buffer tank to achieve longer hydraulic retention or flows directly via gravity to an evaporation bed (Figure 4). The evaporation bed with a surface area of ca. 4 m² shall assure that as much wastewater as possible evaporates and only a small amount infiltrates into the ground. Due to the low wastewater volumes that are to be expected and a partial evapotranspiration at the constructed wetland, the bed is expected to lead to a more or less total evaporation of the treated wastewater. In case the performance monitoring shows a need to reduce the hygienic contamination of the effluent, the installation of UV disinfection can be introduced easily in the effluent chamber. The installation of a UV treatment device would lead to significantly increased energy consumption and increased maintenance efforts.

Costs

The investment costs for the overall sanitation system can be split in three main parts:

- Wastewater and solids collection, storage and solids treatment
- Wastewater treatment
- Wastewater disposal

The costs for the composting toilet have been about 1,500 €/p.e. Despite every mountain refuge is unique in terms elevation, water supply, transport and energy supply, a range for investment costs can be given for different wastewater treatment systems. DAV (2011) give a range of 1,800-3,900 €/p.e. for the investment costs of constructed wetlands at mountain refuges. With about 2,100 €/p.e., the Gloggnitzer Huette constructed wetland lies at the lower end of this range for wastewater treatment. Finally, including the construction of the evaporation bed, total investment costs amounted to 4,000 €/p.e. for the whole sanitation system.

Operation and maintenance

The operation and maintenance is carried out by the voluntary personnel of the alpine association owning the place following a schedule for the operating season. The main efforts for maintaining the sanitation system are:

1. Composting toilet: Addition of a handful of sawdust or ashes after every use by the users; addition of bark or hay once a week by the operators. The rotting chamber is emptied when full and the contents are transferred for further degradation in a composting box. Odour and flies indicate a suboptimal operation due to the lack of bulking material or the presence of non-degradable matter or inhibiting chemicals. The operation of the ventilation system is crucial for the operation; the vents can be pre-set manually to provide sufficient air exchange.
2. Greywater treatment: The mode of operation of the inflow pump has to be adapted according to

the greywater production observed in the buffer tank to avoid dry-out of the constructed wetland. To ensure sufficient treatment, the operators have to carry out monthly measurements of ammonia and settle able solids in the plant effluent. Additionally, the ph and the wastewater temperature are to be monitored. Once a year, the plant operation has to be supervised externally. Regular operation contains monthly checks of the plant inflow, its distribution and pipe cleaning when necessary.

All operation and maintenance activities have to be documented. To increase the knowledge on the systems operation the responsible persons of the alpine association attended a two days training seminar on constructed wetlands.

Summary an outlook

The Gloggnitzer Huette is a good example for many small remote private and public buildings in the Alps. The location in a sensitive drinking water catchment requires state of the art wastewater treatment and disposal. The infrastructure has to work reliably under the difficult conditions of low water and energy availability even though no permanent supervision is possible due to weekend operation only. The chosen system combines different technologies often used in ecological sanitation systems (composting toilet and constructed wetland) and adds up technical components like the volume based flow equalisation with the option to store the wastewater during winter time and solar ventilation of the composting chamber. The discharge of the treated wastewater to the environment is reduced by using a separated evaporation bed. Further treatment (UV disinfection) could be easily installed if necessary. The performance of the described system will be monitored closely to reach optimal performance. Proven successful, the system is expected to be implemented at other comparable mountain refuges in the future.

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