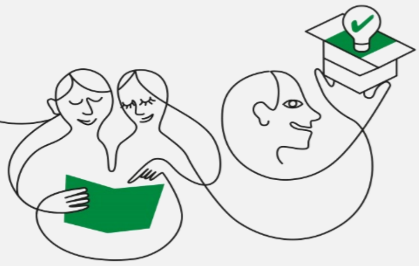

# ECOCAMPING technical information

## Water management and grey water use

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## Conent



The consequences of climate change are clearly visible globally and in Europe. In some regions, people are already affected by severe droughts and are struggling with water shortages. In other regions, infrastructure and houses are flooded and partly destroyed by heavy rainfall events. The cost of water is increasing rapidly. Accordingly, as many as possible implement measures that lead to a careful and respectful use of the resource The use of clean drinking water is not essential for many applications in everyday life, e.g. for flushing toilets and irrigation. The decentralized use of greywater as service water in the public and private sector is one of many solutions whose application is also recommended on a campsite.

Melanie Elba Alicia Strutz has written a master's thesis, in cooperation with the University of Bremen, exemplarily developed a concept for the campsite at Bremen's Stadtwaldsee, which promotes ecological improvements and economic savings. This thesis as well as other literature provide the basis for the technical information, which was created in cooperation with ECOCAMPING.

## 1. Introduction

In terms of quantity, greywater represents the most relevant partial flow of water use in the end-user context with 90%. Furthermore, in a building greywater is always produced separately from blackwater (contaminated with feces) and rainwater. In the sewage system, all streams are brought together and led to the sewage treatment plant as wastewater. Greywater can be reduced to be used as process water after previous treatment. The service water can be used for flushing the toilet, irrigation or cleaning, e.g. awnings. Another reason to return the valuable wastewater partial flow to the water cycle and reuse is the increase of drinking water prices in recent years. Costs for 1m³ of drinking water are exemplified by the development in the federal state of Hessen in the middle of Germany shows (see Figure 1).

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hessen** | | | | | | |
| Fee per m³ and base fee | | | | | | |
| **2017** | 373 | 373 | 5 730 362 | 2,02 | 42,95 | 234,46 |
| **2018** | 373 | 373 | 5 730 362 | 2,03 | 43,89 | 236,35 |
| **2019** | 372 | 372 | 5 721 331 | 2,07 | 47,51 | 243,76 |
| Exclusive fee per m³ | | | | | | |
| **2017** | 50 | 50 | 438 818 | 2,29 | - | 217,11 |
| **2018** | 50 | 50 | 438 818 | 2,31 | - | 219,01 |
| **2019** | 51 | 51 | 447 849 | 2,36 | - | 223,75 |

*Figure 1: Development of drinking water fees in Hessen ((BDEW), 2018)*

The marked column shows the increase of drinking water fees per cubic meter over the years 2017, 2018 and 2019. In the state capital Wiesbaden, the drinking water price was raised again on 01.06.2022 and is currently at 2.41 €/m³.

For the installation and use of a greywater harvesting plant in the public sector, applicable legal framework conditions must be examined. The legal basis for the construction of the greywater harvesting facility on the campsite in Bremen or rather for Germany can be read in the fbr information sheet H 202 (as of 2017). In addition to legal bases, it also contains information on the design of plants for the treatment and use of greywater.

Greywater is to be classified in terms of origin in the two types A and B. Type A describes the weakly loaded greywater flow without kitchen and washing machine drain and type B the heavily loaded flow. Type A1 is grey water from bathtubs and showers. Type A2 also includes the greywater from hand wash basin. Greywater from the sanitary area including washing machine drain belongs to type B1. Type B2 also includes the kitchen drain.

The use of greywater in the public and commercial sector is subject to quality requirements. Depending on the use, the quality levels of the grey water are divided into two classes according to the fbr information sheet H202 and characterized (see Table 1).

*Table 1: Load values for the assessment of greywater quality (fbr, 2017) (DWA - Deutsche Vereinigung für Wasserwirtschaft*, 2017)

| Greywater typee | | | | |
|---|---|---|---|---|
| Parameter | Type A1 | Type A2 | Type B1 | Type B2 |
| Organic load | very low | | moderate to high | |
| COD [mg/l] | 80 – 200 | | 500 – 800 | 400 – 800 |
| TSS [mg/l] | 7 – 120 | | 80 – 280 | 130 – 1300 |
| pH-value | 5 – 8,6 | | 9,3 – 10 | 6,3 – 7,4 |
| Nutrient load | very low - moderate | very low | moderate | high - very high |
| Germ load | very low -moderate | very low | very high | high – very high |
| Specifics | body care products, nutrients and COD possibly higher trough urine | colour, low volume of blood | fluff, detergent, tenside | food waste, fat, cleaner, acid |
| Total coliforms [1/ml] | $10^1 – 10^5$ | | $10^2 – 10^6$ | $10^5 – 10^8$ |
| Faecal bacteries[1/ml] | $10^1 – 10^5$ | | $10^2 – 10^6$ | $10^2 – 10^6$ |

## 2. Greywater Treatment

For the treatment of greywater, different procedures or combined treatment procedures are used in practice. The usual process steps of greywater treatment are the preliminary clarification, the main cleaning, desinfection and storage of the service water (see Figure 2).

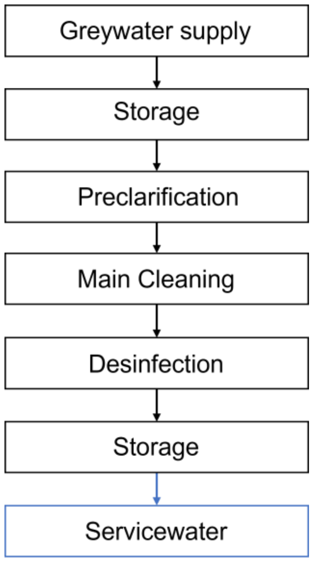



Figure 2:Process steps of greywater treament (own research)

All processes start with the inflow of greywater from the point of origin to the plant. This means that even if a greywater or service water utilisation is not implemented directly in the construction or renovation of a sanitary building, this can be taken into account when planning water supply and discharge. Retrofitting is often a very time-consuming procedure.

Geywater is first temporarily stored and fed to the first cleaning step. The preliminary clarification can be carried out by sedimentation, sieving or filtration. Subsequently, the main cleaning step is carried out under aerobic conditions. Table 2 summarizes common methods of greywater treatment as well as some advantages and disadvantages.

The selection of the process depends on factors such as space or the intended use of the service water. After the main cleaning, the disinfection of the purified water starts. Then the service water is stored in another container and can be used again.

According to the state of the art, a wide variety of biofilm and membrane processes are suitable for the treatment of greywater on campsites.

Biological processes include the wetland and the fixed-bed process (e.g. drip filter process). Membrane processes include inter alica microfiltration. In addition to the technologies that are mentioned, there are others, but they are not presented due to technological progress and parameters such as increased space requirements.

*Table 2: Comparison of processes to treat greywater in accordance with (DWA - Deutsche Vereinigung für Wasserwirtschaft, 2017)*

| Treatment process | Advantages | Disadvantages |
|---|---|---|
| Wetland | frost-resistance, stable in case of inflow fluctuations due to seasonality, low-maintenance | high space requirement, odor |
| Membrane process | appropriate level of cleaning (drinking water quality), low space requirement | high energy demand and and low-maintenance |
| Fixed bed process | low-maintenance | high space requirement |

The purpose of the treated greywater as well as the initial situation of the campsite under consideration is decisive for the selection of the process. The use of a fixed-bed reactor on a campsite which is only operated in the high season, is not recommended. Due to missing guests in the low season: there is no accumulation of wastewater. Drinking water must be fed so that the system does not run dry. Furthermore, the biological process must be maintained by "inoculation".
The microorganism culture and thus also the functionality of the system thus only remain intact if there is a minimum of all-year-round use. This may lead to additional effort and costs, which means that the sustainability effect must also be regarded as critical.
A comprehensive needs assessment is the basis for planning and developing a concept. It must be analyzed at which point and in what quantities greywater is produced per day, the peak loads must be determined and fluctuations, e.g. due to seasonality, but also holidays must be taken into account.

## 3. Needs assessment for greywater use

As mentioned before, data on drinking water consumption provide the basis for a concept to use greywater. For this purpose, the installation of water meters at all sampling points is helpful in order to be able to carry out monitoring. So far, there are hardly any general data for campsites. For this reason, consumption data from the private household are shown in order to make extrapolations about the number of guests (see Table 3).
Here the table of consumption figures of the ECOCAMPING Monitoring can also provide evidence for the planning.

*Table 3: Drinking water consumption in a private household (BDEW), 2020)*

| **Source** | **Quantity of water [l/I · d]** |
|---|---|
| Shower | 10 – 50 |
| Sink (bathroom) | 10 – 15 |
| Sink (kitchen) | 5 – 10 |
| Washing machine | 10 – 15 |
| Toilet flush | 30 – 35 |
| Sum (min.) | 65 |
| Sum (max.) | 125 |

The average daily requirement varies depending on the greywater flow type to be treated (A or B). If only the weakly polluted flow is considered, the drinking water consumption for washing machine, toilet flush and the sink in the kitchen is omitted.

### Steps to implement needs assessments

Assuming that weakly contaminated grey water from the sanitary area without kitchen drainage is used for toilet flushing after treatment further steps of the needs assessment are:

1. Determination of number of guests in the high and low season (daily average)
2. Determination of service water need per day
   - Proceed: Multiplicate average with daily drinking water use for toilet flush
3. Determination of greywater quantity per day
   - Proceed: Multiplicate average with drinking water use for sanitary applications
4. Comparison of results
5. Is a surplus of greywater clearly visible or rather is there enough service water to cover the greywater need or is the addition of drinking water needed?

For the project, no current data were available that could contribute as a basis for the design of a greywater plant on a campsite. The consumption data, which can be taken from the ECOCAMPING environmental report of the campsite at the Bremen Stadtwaldsee from the year 2006, were used (see Table 4). The campsite is no longer part of the network. It should also be mentioned that the campsite is operated all year round.

*Table 4: Consumption data Hanse Camping 2006 (ECOCAMING e.V., 2006)*

| Consumption (total) | | IV/2005 | I/2006 | II/2006 |
|---|---|---|---|---|
| Overnight stays tourists | | 950 | 960 | 3670 |
| **Overnight stays total** | | **950** | **960** | **3670** |
| Inner surface total ($m^2$) | | 700 | 700 | 700 |
| **Water consumption** | [l] | **3000** | **2200** | **5000** |
| Water consumption | [l/overnight stay] | 3,16 | 2,3 | 1,36 |
| Index water consumption | [$l/m^2$] | 4,28 | 3,14 | 7,14 |
| **Wastewater charge** | [$m^3$] | **3000** | **2200** | **5000** |

The table shows a maximum freshwater consumption of 5 $m^3$ in the second quarter of the year. The sampling points are not known in more detail, so that further assumptions would have to be made in order to complete the needs assessment. Here it becomes clear once again how important monitoring is in order to record consumption on site, evaluate it and develop a concept.

## 4. Sustainability of greywater use on campsites

It is obvious that for an investment in a greywater harvesting systems, the financial sustainability must be recognizable, which is becoming increasingly feasible with good planning and estimation of the savings potentials compared to rising water costs. From an ecological point of view, the need for action is obvious and pioneering in the water sector is increasingly being carried out.
In addition to economic and ecological factors, another aspect must be taken into account. The basic concept of sustainability consists of the three pillars of ecology, economy and social affairs. The three-pillar model stipulates that all three pillars are to be regarded as equal.
The social aspect is less taken into account in most cases. It is predicted that in 50 years about 40% of the world's population will be affected by drinking water shortages. Europe and Germany are also increasingly affected by this.

In addition, about 2.2 billion people worldwide do not have access to fresh water and the use of sanitary facilities is still insufficient in many parts of the world, which requires a careful use of the resource. We must increasingly strive to close open cycles in all areas of life.

Grey water is continuously available in trade, households and public facilities equipped with sanitary facilities. Re-use conserves groundwater reserves. The total amount of wastewater as well as the reduced dirt load in the wastewater stream relieve the entire sewer network as well as the sewage treatment plants. The necessity of drinking water to flush the toilet is justifiably called into question by the implementation of innovative sanitary systems. Before water becomes drinkable long distances often have to be covered to the waterworks. More than 80% of drinking water provided by Bremer Stadtwerke is produced from the surrounding area. The treatment process of drinking water is complex and the financial effort is huge. This could be reduced by reusing grey water. Where does the water come from and how elaborately does it have to be treated?

In order to consider ecological sustainability, the material and energy costs of drinking water treatment would have to be compared with the costs of greywater treatment. This comparison would exceed the expense of the technical information. In summary a statement about economic sustainability can be made.

If the system is used according to the manufacturer's recommended use and all requirements can be met, water savings are possible after deduction of all costs (operating and maintenance costs). Further savings could be achieved through heat recovery. However, this depends on the respective system and the campsite (e.g. seasonality). By using more greywater sources at the campsite, a larger system could be used, which is expected to enable higher drinking water savings. In general a system runs more stable with a higher amount of greywater and thus also more efficiently. Also the prescribed maintenance intervals must be adhered to. Visual inspections of the technical components by the campsite operator are also recommended in order to reduce the maintenance effort if necessary.

Example projects from recent years have shown that with sufficient planning and oversizing of a greywater system, errors can occur, which leads to the decommissioning of the system or a large number of adjustments that are time-consuming and costly.

Statements about the payback period of greywater systems cannot be made. However, the literature shows a period of 8-10 years.

Considering that it can nevertheless be said that the construction and operation of a greywater utilisation plant on the campsite at Bremen's Stadtwaldsee would be sustainable from an economic point of view, taking into account the assumptions made in the concept draft.

## 5. Examples of the feasibility of a theoretical concept

As described at the beginning, the design of a greywater use concept is presented as an example, which was adapted to the campsite on Bremen's Stadtwaldsee. According to the fbr information sheet H 202, a large amount of information is required for the design of the system, which is compiled below:

## 6. Operation: annual

- Surface of the entire area: 6 hectare
- Estimated surface of the sanitary building: 610 $m^2$ (at ground level)
- Presumed need of service waster in the high season: 4,48 $m^3$
- Presumed need of service waster in the low season: 1,6 $m^3$
- Presumed greywater amount in the high season: 5,18 $m^3$
- Presumed greywater amount in the low season: 1,85 $m^3$
- Selection of membrane filtration to treat the greywater
- Selected manufacturer: Greenlife GmbH
- Cleaning power: 5 $m^3$/d

With the help of 3D modeling, it will be shown at which point the grey water is brought together in the sanitary building. For this purpose, Figure 3 shows the exterior view of the building as well as a derived sketch with all the rooms.

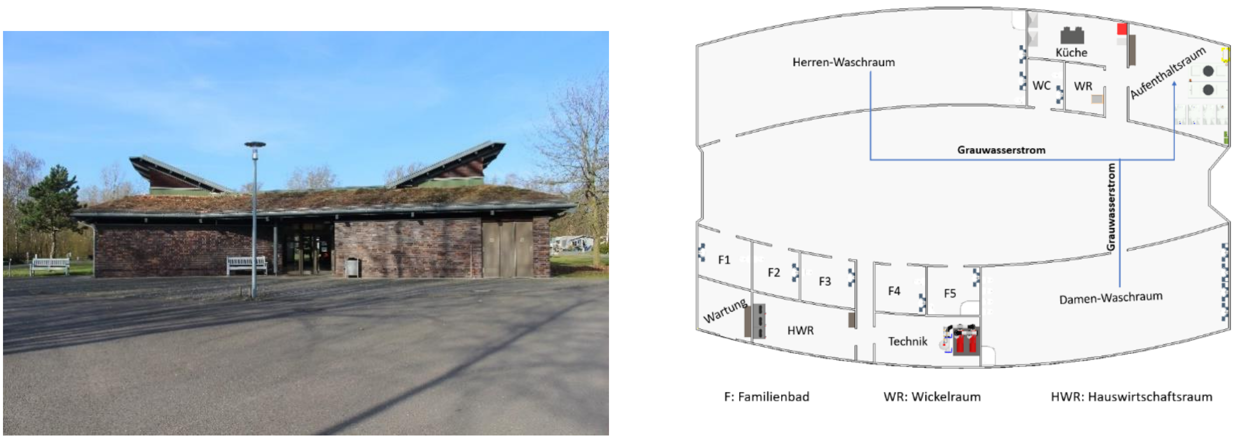
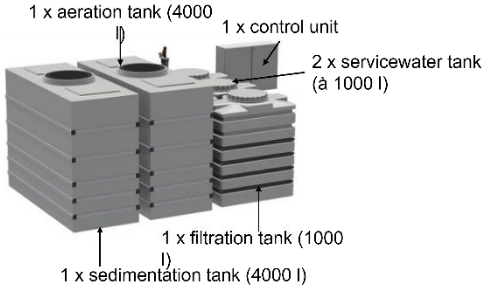



*Figure 3:Outer view (left) and schematic view (right) of the sanitary building*

After selecting the treatment method (ultrafiltration) it was determined that the greywater treatment plant from Greenlife GmbH should be used. Table 5 below provides information on the most important technical details of the plant.

*Table 5: Technical details (greywater treatment plant from Greenlife GmbH (Greenlife GmbH, 2015)*

| Criteria | Greenlife GmbH | Figure |
|---|---|---|
| Cleaning power | max. 5 $m^3/d$ |  |
| Investment costs | 24.995 € | |
| Energy demand of the plant | 0,8 – 1,2 $kWh/m^3$ | |
| Pretreatment | Sedimentation | |
| Volume greywater tank | - | |
| Volumen sedimentation tank | 4 $m^3$ | |
| Volume aeration tank | 4 $m^3$ | |
| Main treatment | Ultrafiltration | |
| Volume filtration tank | $2 \cdot 1\ m^3$ | |
| Pore size of the membranes | 35 nm | |
| Volume servicewater tank | $2 \cdot 1\ m^3$ | |
| UV desinfektion | Not included | |
| Pressure booster system | Not included | |
| Length | 3620 mm | |
| Wide | 2560 mm | |
| Height | 1950 mm | |



The company Greenlife GmbH has been active in the field of greywater treatment for several years. A reference project can be found at the Radisson Blu Hotel in Zakopane (Poland). Up to 20 $m^3$ of greywater from showers and washbasins are recycled daily with the help of an membrane bio reactor and used again as toilet flushing water.

## Costs of investment

As part of the research work for the completion of the concept design, costs incurred for the installation and operation of a greywater harvesting plant could be determined. It is assumed that the presented system of the company Greenlife with a cleaning capacity of 5 $m^3/d$ is used.
The costs of investment consist of the costs for the system technology of the entire system as well as the costs for the conversion of the recreation room and the construction of the second pipeline network. The sum results from the list of the mentioned cost centers in Table 6.

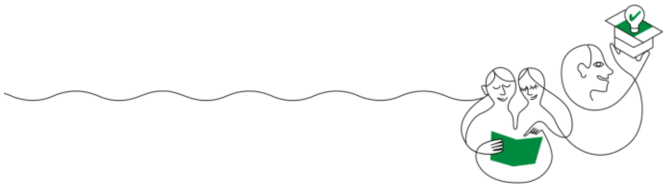


*Table 6: Composition of investment costs*

| Item | Price (netto) in € |
|---|---|
| Greywater treament plant (Greenlife GmbH) | 24.995,0 |
| Desinfection unit | 560,5 |
| Service and montage set | 46,7 |
| Pressure booster system | 1.260,0 |
| **Subtotal** | **28.862,2** |
| Costs of reconstruction (lounge) | +3454,5 |
| Costs for the expansion of a second pipeline network | +9.150,0 |
| **Subtotal** | **39.466,70** |
| Expected costs of installation (4% of subtotal) | +1.578,67 |
| Subsidies | -5.000 |
| **Sum spent for investments** | **36.045,37** |

The subsidy amount depends on the respective region and funding programs. In the federal state of Bremen, up to 40% of the total sum and a maximum of € 5,000 are funded. For the case under consideration, this corresponds to about 12% of the investment costs. Basically, it is recommended to review further funding options to be able to supplement the greywater use concept if necessary.
The costs for the construction of the second pipeline network for the reconstruction of the sanitary building would be obsolete in a new building, so that the sum of the investments would also be lower.

## 7. Further examples and information sources

There are already campsites that treat and reuse grey water. Camping Gerhardhof in Tyrol is also part of the ECOCAMPING network. Weakly contaminated grey water from hand washbasins and showers is used here after treatment as service water for flushing the toilet. The Campsite Hofgut Hopfenburg has also installed a greywater treatment system in 2022, but the pipes would be laid years before during the construction of the sanitary building. Due to such long-term planning, the investment costs are much lower. The conscious use of water and the high value of wastewater streams should also always be improved by targeted environmental education of guests and employees. The technologies for the use of grey water are already there, humanity must act immediately, because our water supplies are finite!

Further information: can be found here

- Fachvereinigung Betriebs- und Regenwassernutzung e.V. (www.fbr.de )
- Förderungsprogramme für die Implementierung von Grauwassernutzungsanlagen (www.foerderdatenbank.de/)

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**Impressum**

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