# Combined greywater treatment using a membrane bioreactor

Author: Sellner


## Abstract

The daily fresh water consumption can easily be reduced by using greywater from showers, bath tubes and wash basins, when substituting drinking water e.g. for toilet flushing, garden irrigation, cleaning purposes or industrial cooling- processes. The ecological and economic advantages of the *GEP- Watermanager* open up new possibilities of an intelligent water management. It combines a greywater- recycling- plant with rainwater management, drinking water management, a booster station and a remote control module. Based on a modular construction concept the *GEP- Watermanager* is operated as a membrane bioreactor with submerged ultra filtration membranes for precious process water. The attained output values after the recycling process are substantially below the strict limits set by the EU bathing water regulation. The little footprint and optimised energy consumption of the *GEP- Watermanager* accompanied by high filtration performance offers new interesting alternatives for in- building solutions for a decentralized water management.


## The GEP- Watermanager

Since 1992 the German company GEP Umweltechnik GmbH develops and distributes solutions for an optimised water management. The first satisfying success in developing a secure in house greywater plant, based on a membrane bioreactor, took place in 2002. This was the hour of birth of the *GEP- Watermanager WME 4* – recycling with *BioMembranTechnologie® (BMT®)*.
In the meantime the process of improvement and development moved strongly forward and today GEP is able to offer fully automated, remote monitored and high efficient greywater plants for in- and outdoor installations. The *GEP- Watermanager* is designed as a modular construction and allows building contractors and engineers a wide scope of design possibilities.
The classical layouts of greywater plants by GEP are shown in Table1 in association with their main specific parameters.

**Table1: *GEP- Watermanager* - main specific parameters**

| Model | Filter performance [l/d] | Greywater- tank [l] | Processwater- tank [l] | Energy consumption* [kWh/m³] | Footprint** [m²] |
|---|---|---|---|---|---|
| GEP- Wassermanager WME 4 | 800 | 250 | 125 | 3,67 | 1,5 |
| GEP- Wassermanager WME 15 | 700 | 750 | 500 | 3,29 | 2 |
| GEP- Wassermanager GWA 1 | 1.400 | 1.100 | 1.100 | 4,2 | 4,5 |
| GEP- Wassermanager GWA 2 | 2.800 | 1.100 | 1.100 | 2,8 | 4,5 |
| GEP- Wassermanager GWA 3 | 4.100 | 1.500 | 1.500 | 3,1 | 5 |
| GEP- Wassermanager GWA 4 | 5.500 | 1.500 | 1.500 | 2,7 | 6,5 |
| GEP- Wassermanager GWA 5 | 7.200 | 2.000 | 2.000 | 2,9 | 7 |
| GEP- Wassermanager GWA 6 | 8.500 | 3.000 | 3.000 | 2,6 | 7,5 |

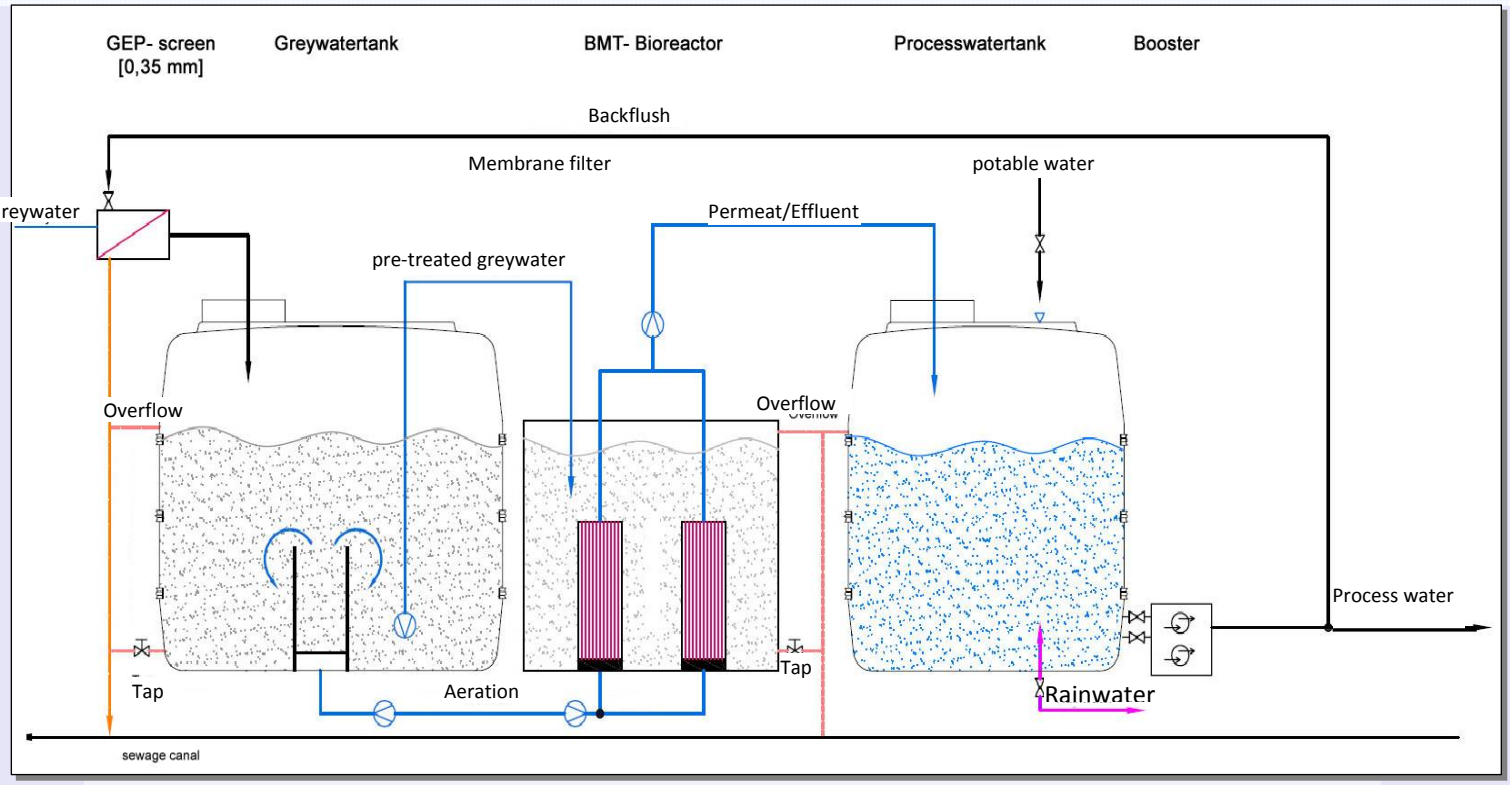


**Figure 1: Principel flow chart of the *GEP- Watermanager***

The principle flow chart of *GEP- Watermanager* is shown in Figure1. First of all the separately collected greywater from showers, bathtubs and wash basins pass through a screen with a mesh size of 0.35 mm. The solids will be removed and automatically flushed into the sewer (Figure2). The pre-treated greywater flows into the first greywater tank, where bacteria with the help of artificially supplied oxygen begin to degrade the organic substances contained in the greywater.

After a short interval of sedimentation and flotation the biological treatment continues in the *BMT*® - Bioreactor with the biological aerobic degradation. The *BMT*® - control panel monitors and calculates permanently the optimal hydraulic retention time for high biological removal performance to achieve a long storable and odourless process water.

**Figure 2: The GEP- *TridentMAX*, a screen with an mesh size of 0.35 mm separating the raw greywater from the solid ingredients**

Due to the low organic loading rates in greywater (≤ 0,1 kg COD/kg/d) (Paris and Schlapp, 2009) and the high solid retention time in the *BMT*® - Bioreactor the growing rate of biomass is limited too (MLSS≈ 1-5 mg/l) (Sellner, 2009). As a consequence the growing rate of biomass is low and the period of removing sludge in the tanks is once in a year or even longer.

After the biological treatment the heart of the *GEP- Watemanager*, the submerged ultra-filtration starts its work in the *BMT*® -Bioreactor. The European patented *MicroClear*® -filter represents a true physical barrier which blocks all germs and suspended matters (Figure 3). The minute pores of only 50 nm exceed the requirements of the EU bathing water guideline 2006/7/EG (2006) and even the DIN 19650 (1999) class 2 requirements for irrigation water.

The optimised aeration (with continuously-rising, fine air bubbles spaced at intervals) ensures a permanent self- cleaning effect on the filter plates that reduces the need of chemical cleaning to an absolute minimum. In combination with a low negative pressure (0.1 bar) during the filtration process (Figure 4) and a relaxing period (aeration without filtration) the membranes lifetime achieve terms of 8 to 24 months. If the filter should be dirty, it is simply replaced by a filter that has been

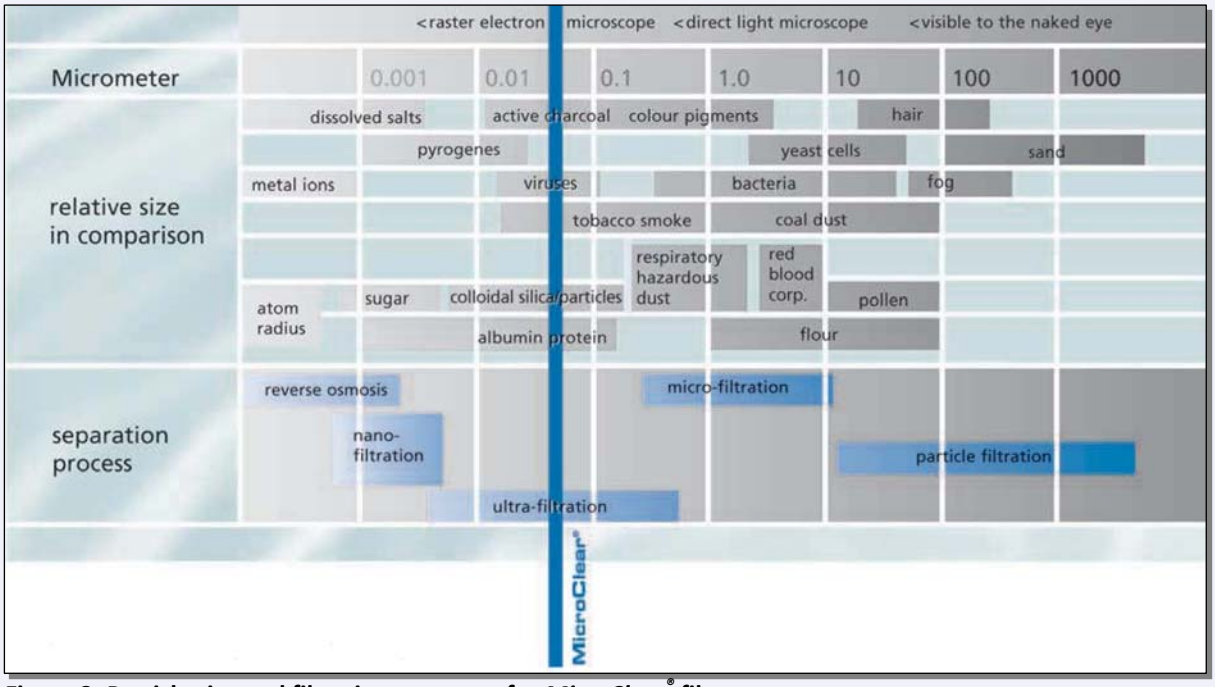


**Figure 3: Particle size and filtration spectrum for *MicroClear*® filters**

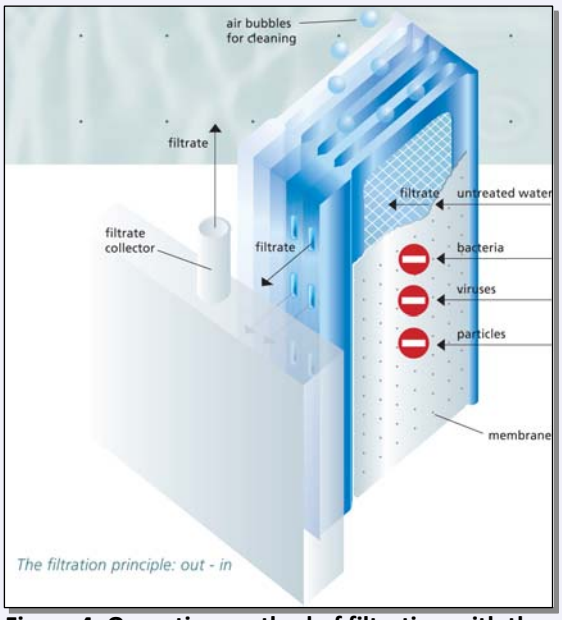


**Figure 4: Operation method of filtration with the *MicroClear*®**

thoroughly cleaned. This permits to have a lifetime of up to 10 years per filter.

The result of this unique and safe process is a nutrient-poor, odourless, purified process water for further applications. In Table 2 the results of a nine week measurement in a student dormitory are shown. In addition to that the process water qualities guaranteed by GEP, according to the information sheet (FBR-Hinweisblatt H201, 2005), will be mentioned there as well.

The process water will be stored in a process water tank until its delivery by a booster- system to its consumers. In case of a lack of process water the requested amount of water will be automatically substituted by drinking water according to DIN EN 1717 (2001).

The control of the *GEP- Watermanger* provides user friendly completely automated and remotely operated maintenance of a high technology greywater treatment plant. It is possible to observe, to evaluate and to control the *GEP-Watermanager* entirely from the office or control centre. Hence the best moment to change the filter can be detected which economizes real maintenance and operation costs.

The *GEP-Watermanager* is quite more than an ordinary greywater treatment plant. At the same time it can be operated without any problems with drinking water, greywater, process water and rainwater. In the opinion of GEP the bonding of greywater- recycling and rainwater harvesting is currently the most sustainable manner of decentralized water management.
For this reason the *GEP- Watermanager* is composed of systems by greywater management, rainwater management, drinking water management, booster station and remote control module. The convincing modular concept and the flexibility in tank versions allow building contractors and engineers the greatest scope for designing their own individual *GEP- Watermanager* according to the current circumstances.

| | Greywater | | Processwater | |
|---|---|---|---|---|
| Parameter | Student dormitory | H201 | Student dormitory | H201 |
| COD [mg/l] | 186 ± 65 | 150 – 400 | 11 ± 2,9 | |
| BOD [mg/l] | 136 ± 10 | 85 – 200 | 2,9 ± 0,8 | < 5 |
| pH | 7,58 ± 0,11 | 7,5 – 8,2 | 7,55 ± 0,4 | |
| Temperatur [°C] | 27,2 ± 0,6 | | 22,7 ± 2,3 | |
| Total coliform bacteria [1/ml] | | | 40 ± 24 | < 100 |
| Faecal coliform bacteria [1/ml] | | | 2 ± 2 | < 10 |
| | | | Processwater quality after 14 days storage | |
| Total coliform bacteria [1/ml] | | | 9 ± 8 | |
| Faecal coliform bacteria [1/ml] | | | 0 | |

**Table 2: Results of a nine week measurement in a student dormitory with 174 residents (Sellner and Schildhorn, 2009) compared with the recommended values of process water (FBR-Hinweisblatt H201, 2005).**

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**Name:** Markus Sellner
**Organisation:** GEP Umwelttechnik GmbH
**Town, Country:** Eitorf, Germany
**e-mail:** info@gep.info