

**018**  
**Greywater recycling in**  
**Hotel ArabellaSheraton**  
**Am Büsing Palais**  
**Offenbach, Germany**

ECOSAN SYSTEM		SOLID BIOWASTE	FAECES	URINE	GREYWATER	RAINWATER
APPLIED COMPONENTS	COLLECTION				Separate greywater collection	Separate rainwater collection
	TREATMENT				Multi-stage biological treatment in combination with UV-disinfection	
	UTILISATION				Toilet flushing	Watering green areas

**1 General Data**

**Type of Project:**  
 New construction project in a 4-star hotel

**Project Period:**  
 Start of construction: 04/1995  
 Start of operation: 01/1996

**Project Scale:**  
 20 m<sup>3</sup> /d greywater from a 380-bed hotel facility

**Address:**  
 Am Büsing Palais, Berliner Straße 111  
 Offenbach, Germany

**Planning Institution:**  
 Ingenieurbüro Nolde & Partner

**Executing Institution:**  
 ArabellaSheraton Frankfurt



Figure 1: Hotel ArabellaSheraton, Offenbach (source: GTZ)

**2 Objectives**

- Reduction of drinking water consumption and wastewater amount to be discharged to sewer through recycling greywater for internal re-use.
- First trial and demonstration of a new greywater biological treatment technology.

**3 Location and general conditions**

Hotel ArabellaSheraton Am Büsing Palais Frankfurt is a 4-star hotel located in Offenbach, an outskirt district to Frankfurt metropolitan area. It has a capacity of 380 beds.

When the construction of ArabellaSheraton in Offenbach was planned, the greywater collection, treatment and recycling system was not included. The idea came out during the hotel construction process. So the existing system

was built in the garage on two parking lots.

According to the initial design wash basins were placed at the opposite site from baths/showers, so the greywater from wash basins was not included in the greywater recycling system, for the reason of sparing extra draining pipes. Besides recycled greywater from bathes and showers is enough for toilet flushing.

**4 Technologies applied**

Greywater from baths/showers in the guest rooms is separately collected and transferred to settling tanks. After preliminary sedimentation the greywater is treated continuously in a six-stage Ro-

tating Biological Contactor (RBC) system.

In the biological cleaning units large surface area of rotating polyethylene carriers accommodates and promotes growth of characteristic bacteria. Those bacteria consume the biologically degradable pollutants in greywater for microbial metabolism. The oxygen necessary for microbial activities is brought in by the revolving rotors. The surplus biological sludge is then settled down and discharged to the sewerage every three months.

The biologically treated greywater outflow is disinfected by means of UV-radiation through the UV-reactors. The

commissioned by

ecosan program  
 recycling oriented  
 wastewater management  
 and sanitation systems

Federal Ministry  
 for Economic Cooperation  
 and Development

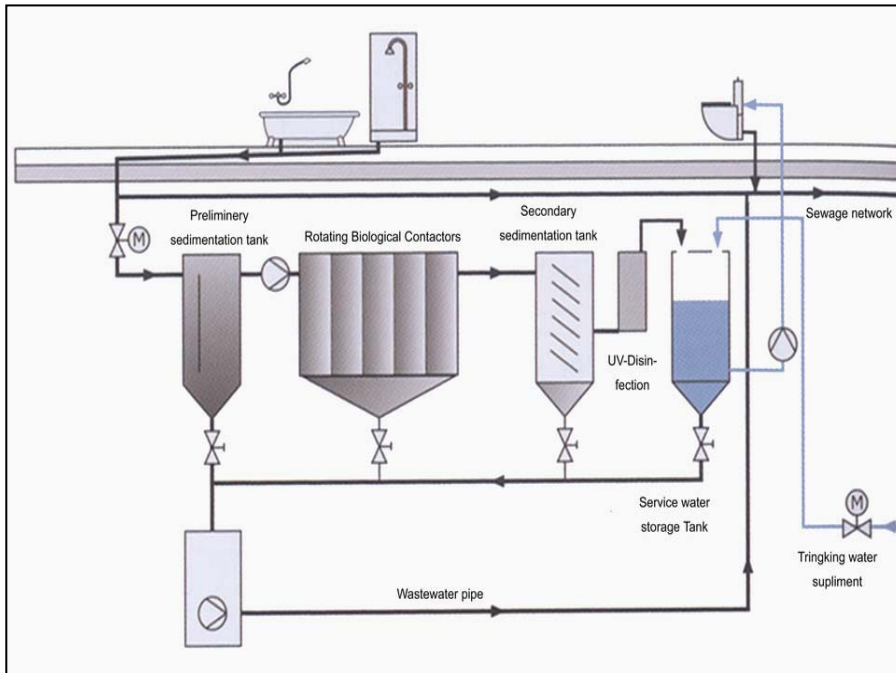


Figure 2: Greywater collection, treatment and recycling process (DVA)



Figure 3: Biological treatment unit (source: Nolde &amp; Partner)

efficiency of the UV-disinfection is controlled by an optic sensor. When a disturbance is detected, the greywater will not be channelled into the service water tank but to the wastewater pipes.

The disinfected water is stored in a service water tank, from where the water is pumped into the separate main network for service water and distributed for toilet flushing.

The storage tanks are automatically replenished with drinking water when the service water inside is in shortage.

## 5 Type of reuse

Rainwater from the roof of the hotel is collected and stored in a rainwater storage tank. It is used for watering green areas.

Wastewater from wash basins and other sources are collected and channelled to centralized municipal wastewater treatment facilities.

The treated greywater is reused for flushing the toilets from 221 guestrooms in the hotel. During the past ten years, around 5.000 m<sup>3</sup> of drinking water have

been saved annually by substitution with treated greywater.

When the service water tanks are full, greywater will be directly diverted to the sewage net without entering into the treatment system. At that moment the treated greywater is in surplus and rainwater collected is also sufficient for watering plants.

## 6 Costs

The total investment of the project is about 170.000 Euro, of which the net cost of the greywater recycling system is 72.000 Euro. The rest is for additional pipes, additional cost of construction, planning and design, etc.

The present price of drinking water in Offenbach is around 6 Euro/m<sup>3</sup> for business /industry uses, including wastewater fees.

Based on this calculation, about 30.000 Euro can be saved every year, from which annual costs for operation and maintenance of around 4000 Euro have to be deducted.

## 7 Operation and Maintenance

All units function automatically and are made of high-grade industrial components which do not require a special maintenance. The micro fauna of the RBC regulates itself naturally and the accumulated biological sludge is let off regularly. The pumps are regulated by pressure and water current. The UV-reactor runs continuously. The maintenance consists of a regular plant control and simple cleaning activities which can be performed by the user.

Routine inspection that lasts about half an hour by one maintenance staff is performed weekly to check the colour, layer thickness and structure of the biomass and network leakage, water level of the tanks, malodours, etc. In addition, the maintenance staff is responsible for the quarterly maintenance and the annually maintenance is done by the provider.

The whole system is under operation 365 days per year. Normally change or repair can be done while other parts are still operating.

Energy required is 0,135 wh/m<sup>3</sup> treated greywater (source: Nolde & Partner).

## 8 Design information and technical specifications

The greywater collection, treatment and recycling system is designed for a capacity of 20 m<sup>3</sup>/day (400 beds). It takes

Table 1. Cost and benefit (source: Nolde &amp; Partner)

Items		Annual cost (euro/a)
<b>Initial investment</b>		
Treatment system	72.000 Euro	
Pipe system, planning and others	ca. 100.000 Euro	
<b>Operation cost</b>		
Energy cost	Energy demand: 0,135 kwh/m <sup>3</sup> treated greywater Electricity price: 0,3 Euro/kwh	200
Internal maintenance cost	0,5h/week 40 Euro/h	1040
Maintenance by provider	1.200 Euro/a	1.200
Repair cost	2% of treatment system cost /a (in the first 6 years)	1.440
<b>Cost saving</b>		
Reduction of drinking water consumption	5.000 m <sup>3</sup> drinking water per year Drinking water price: 6 euro/m <sup>3</sup>	30.000

35 m<sup>2</sup> to place the treatment facilities.

It was designed on an estimation of 70 to 90 liter of greywater to be produced per day per person and 50 to 70 liter water required per day per overnight for toilet flushing. There were no existing legal minimum quality requirements for recycled greywater in Germany, but the quality of the treated greywater was designed to meet the specific quality standards issued on a leaflet by the Berlin Senate Department for using recycled greywater in building and housing (source: Nolde & Partner). A comparison between those standards and the quality of outflow is made in table 3. It shows that the biological treatment is highly efficient.

Only environmentally sound and corrosion resistant materials are employed: PE and polypropylene (PP) tanks, PE bio-rotors, stainless steel V4A shafts and bearings, zinc-plated steel fittings for the tanks, and PE, PP, stainless steel and copper pipes.

Table 2: Technical design specification (source: Nolde &amp; Partner)

Greywater collection pipes	DN150 ×2
Primary sedimentation tanks	6,8 m <sup>3</sup> in total
Rotating Biological Contactor	1 m <sup>3</sup> of each HRT: 8h
Secondary sedimentation tanks	6,8 m <sup>3</sup> in total
Power of UV disinfection	50 Watt

## 9 Practical experience and lessons learned, comments

The cleaned greywater is odourless, clear and free of suspended material. The user suffers no loss of comfort in comparison to the use of drinking water. According to the hotel, no customer complained.

The primary settling tanks originally installed were market products for rainwater storage. They were made from recycled polyethylene (PE). After some time of operation the first two tanks cracked due to insufficient quality and

were replaced by new PE tanks. The new tanks are functioning well.

The two motors for RBC units were replaced by other type of motors due to their incapability of regulating the rotation speed of the contactors.

The first rotor of a RBC unit was broken after some time due to unbalanced heavy weight brought by the wet bacteria while the contactor rotates. For this reason it was repaired.

In the last ten years, aside from several problems stated above, the whole system was working quite well.

## 10 Available documents and references

Website: <http://www.graywater.com>

Nolde, E., Greywater reuse systems for toilet flushing in multi-story buildings - over ten years experience in Berlin. Urban Water, Volume 1, Issue 4, December 2000, P. 275-284

Nolde, E., Greywater recycling – ecological, technical and economic aspects with case study (in German), downloadable from <http://www.nolde-partner.de>

Nolde, E. Grauwassernutzung im Arabella-Sheraton Hotel Offenbach

## 11 Institutions, organisations and contact persons:

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Table 3: Quality of outflow of the treated greywater (source: Nolde &amp; Partner)

Quality standards	Indicators	Criteria	Outflow quality
Hygienically /microbio-logically acceptable	Total Coliform bacteria	<100/ml	<0.1/ml
	E. coli	<10/ml	<0.03/ml
	P. aeruginosa	<1/ml	<0.1/ml
Low BOD	BOD <sub>7</sub>	< 5mg/l	< 3mg/l
Colourless and clear	UV-Transmission (254nm)	> 60%	/
Oxidized	saturation	>50%	>70%



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data sheets for ecosan projects

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