How Rainwater is used in a German Hospital

EMAS Certification, Water efficient and Energy saving

Building services and modern medical technology are complex issues in a hospital. A work group for environmental protection was organised in the clinic as early as 1988. And the management has pursued a stringent quality management concept for many years already. Certification of the clinic as a whole with respect to environmental management (re-certification, EMAS II), certification of the central sterilisation facilities according to DIN-ISO as well as integration of a RISK management system were the pre-requirements for the establishment of a comprehensive quality management system. The technical department, which is responsible for procurement and maintenance, is also responsible for the most recently published environmental statement, in 2011 [1].

In 1995, when the clinic in Bad Hersfeld was still operating as the general county hospital, it benefited from the subsidies set up by the Federal State of Hesse and installed a rainwater harvesting system during a first phase of construction (**Figure 1**). This was subsequently expanded in 2001 and 2008. Today, 15 clinics operate under a single roof. Thanks to its wide range of medical and healthcare services and currently 577 hospital beds, Bad Hersfeld Clinic is the main medical competence centre for eastern and central Hesse. With roughly 1800 employees, it is one of the region's biggest employers and a significant economic factor.

Wage settlements with rising salaries for hospital doctors, less services covered by health insurers, less beds available and increasing investments in medical devices – hospitals are coming under more and more financial pressure. Both, privately and state-run institutions focus their attention on operating costs, especially those for energy and water. Rainwater harvesting represents a possibility to save money on electricity, drinking water and precipitation fees.

Rainwater utilization in a hospital?

In 1996, in its guide entitled "Die umweltbewusste Gemeinde" [2] (Transl.: An environmentally-aware state) the Bavarian Ministry of State for Regional Development and Environmental Affairs wrote the following: "Install model facilities in public buildings. Benefit from the fact that these buildings are open to the public and can be used to publicize the concept of rainwater harvesting. Using rainwater from the roof is not only permitted in administration buildings, but also in community buildings, including buildings that are required to satisfy special hygienic requirements, such as hospitals, old people's homes, schools and nurseries (**Figure 2**).

And still, this must be handled very carefully, as hygiene problems, which can arise if pipes for drinking water are incorrectly connected to those for rainwater, do not simply affect a larger amount of people, but people who tend to be more susceptible to health risks. Providing the specifications stipulated for the construction and operation of rainwater harvesting systems are complied with, the head of the institution is authorised to decide whether to install this kind of system or not."

Hygiene

Surveys and favourable opinions on the safety of such systems were the kinds of decision aids available in the mid-90s in Hamburg, Bremen, Hannover, Fulda and Stuttgart [3]. The last few years, however, have seen a downward trend in rainwater harvesting. With the coming into force of the Drinking Water Ordinance on 1st January 2003, which, corresponding to the DIN 1989-1 directive of April 2002, permits rainwater to be used in buildings to flush toilets, wash clothes and water gardens, discussion about hygiene issues has died down. "When everyone was talking about this topic in the 90s, when the domestic use of rainwater was still contended, our sales figures were only marginally lower than figures today," says *Jan Maurer,* from Wisy AG, in Kefenrod, Germany. The former high

Figure 1: Klinikum Bad Hersfeld, aerial sourcegraph (source: Clinic in Bad Hersfeld)

Figure 2: Klinikum Bad Hersfeld (source: Sperfeld)

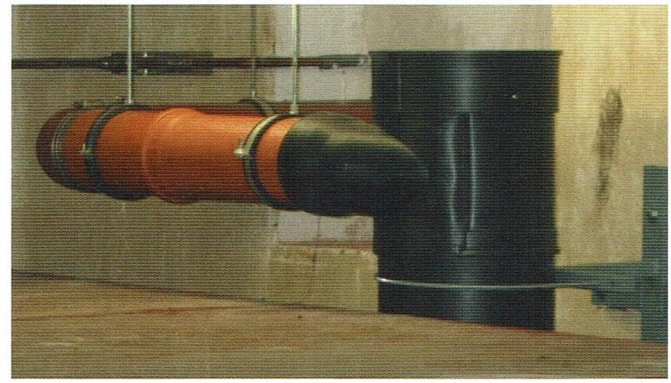

Figure 3: Klinikum Bad Hersfeld, self-cleaning vortex filter for rainwater, installed in feed pipe leading to steel tank (source: www.wisy.de)

demand was certainly also due to considerably more privately-owned homes being built, and due to state-wide subsidies granted by the state of Hesse between 1992 and 1996 for utilizing rainwater, before the era in which *Roland Koch* became minister-president for Hesse.

Project funding from groundwater extraction fees was able to be used in Hesse from 1992. According to an appraisal in 1997, a total of 410 rainwater systems were funded in public buildings through fixed subsidies, including schools, town halls, community buildings, utility buildings, cemeteries, construction sites, communal and sports halls owned by clubs, etc. The Protestant Evangelical regional association, umbrella organisation of the 72 parishes and social institutions in Frankfurt, launched a program in 1996 to save water including rainwater utilisation for its 500 parish buildings, children's nurseries, health and advice centres, churches and other buildings.

Water demand

Heiko Kohlrenken, 2005–2013 officer for environmental management and technical director at the clinic in Bad Hersfeld: "Our overall water consumption has decreased 2003–2007 from 3.06 m^3 per in-patient to 2.69 m^3." Use of rainwater to water the grounds was introduced during the first construction phase as early as 1995. A fountain and pond are also fed with water from the cisterns. Since 2001, 71 toilets have been supplied with rainwater by the system (**Table 1**). In 2008, another 40 toilets for a 140-bed ward in the south part of the building were connected up to the rainwater system. This brought in further savings of 1613 m^3 per year. Calculations were based on four flushes of eight litres each per bed per day, 360 days of the year.

According to *Kohlrenken*, the cooling system for vacuum pumps used in the sterilisation process is particularly effective. According to the manual published by the sterilizer manufacturer, 4000 m^3 of softened water at a maximum of 14 °C were previously used on an annual basis, and subsequently fed warm into the sewage system. Today, rainwater flows through a closed circuit at 20 °C into the cisterns, where the waste heat is dissipated. To keep the circulating water fresh, a certain share of the cooling water that is fed into the circuit, is gradually replaced.

Compared with an approximate 80000 m^3 of drinking water consumed in 1992, only 60000 m^3 were needed per year in the buildings monitored at the time. Of the 20000 m^3 of drinking water saved, 20 % (4000 m^3) were saved from applying rainwater cooling technology.

Fees saved in one year

A volume of 2 564 m^3 was extracted from the cistern. 384 m^3 of drinking water had to be resupplied during dry periods, leaving a used rainwater yield of 2180 m^3. Add to this the 4000 m^3 that are saved with regard to cooling water, and the volume of water totals 6180 m^3. At a price of drinking water of € 2.12/m^3, costs have been reduced by € 13 101.60. Since 1st January 2003, the clinic has also profited from an amendment to the statutes of the city of Bad Hersfeld. In 2007, rainwater was accounted for on a

Figure 4: Sectional drawing of self-cleaning vortex filter for rainwater, installed in feed pipe leading to steel tank (source: www.wisy.de)

source-related basis at a price of € 0.66 for each square metre of sealed area that was drained into the sewage system. Cisterns designed for rainwater usage that include a sewer junction, as used here in the clinic, can accommodate a roof area of 15 m^2 for each cubic metre of holding capacity. The rainwater storage tank, which holds 45.4 m^3, therefore leads to a reduction of 681 m^2 or in other words, € 449.46 less precipitation fees. Together with drinking water fees, Bad Hersfeld Clinic saved € 13 551.06 in 2007 by using rainwater! Operating costs, including filter maintenance and electricity for the rainwater pumps, were largely offset by the fact that the drinking water no longer had to be softened for the cooling process.

Rainwater technology

The rainwater storage tank, which was created in 1995, is made of steel. The battery of tanks that was additionally installed in 2001 comprises eight plastic tanks. Both storage systems are connected to each other and both collect rainwater. Before the rainwater enters the cistern, it goes through a filter (**Figure 3**). A filter is an important component of a rainwater harvesting system, as it contributes to the quality of the water and trouble-free operation of the system (**Figure 4**). The vortex filter principle, which is applied in this system, was invented in Vogelsberg just in time before the boom began in the 1990s. And provided a solution to "square the circle": the filter sleeve is a cylindrical, perforated component with a filter mesh of 0.28 mm, which snugly lines the wall of the feed pipe without narrowing the cross-section of the pipe. It enables dirt to be removed (filter type C in accordance with DIN 1989-2:2004-08). Filtered particles are swilled into the sewer pipe without blocking the filter or having to be disposed of. This results in a highly effective system with a long useful lifetime, i. e. a large water yield, good purification and low on maintenance. In compliance with DIN 1989-1 a filter has to be cleaned at least once a year. This kind of vortex filter is also in continuous operation in industrial units, and is cleaned automatically by a spray nozzle.

Amortisation

Heiko Kohlrenken evaluated the rainwater/operating water technology for the year

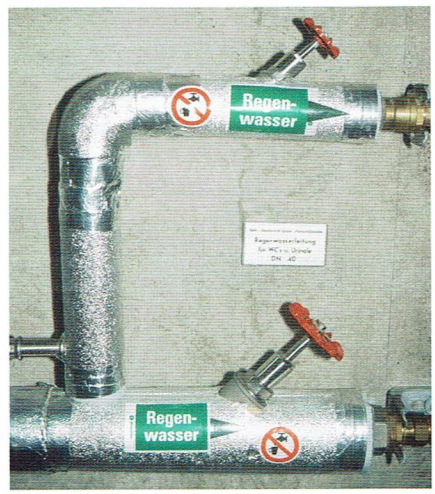

Figure 5: Pipes carrying rainwater have to be labelled differently to drinking water pipes, e. g. by affixing stickers (source: Koenig)

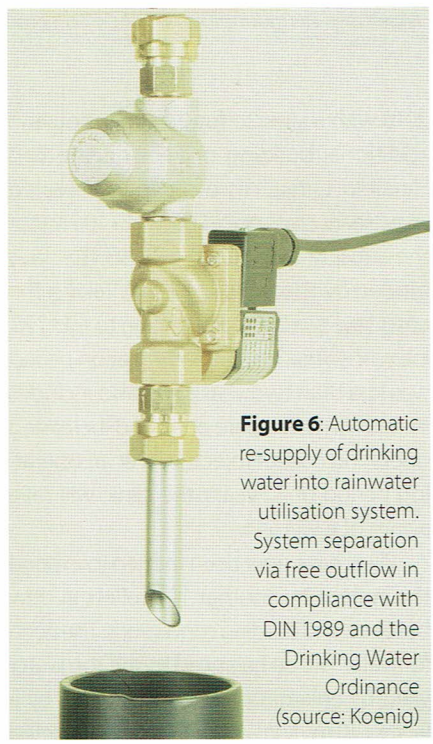

Figure 6: Automatic re-supply of drinking water into rainwater utilisation system. System separation via free outflow in compliance with DIN 1989 and the Drinking Water Ordinance (source: Koenig)

Bacteriological standards and threshold value			
	Water used for swimming		Median values of 102 cisterns of a prolonged test period
	Regular	Maximum	
Escherichia coli	100/100 ml	2,000/100 ml	26/100 ml
Coliform bacteria	500/100 ml	10,000/100 ml	198/100 ml

Figure 7: Comparison of the quality of bathing water and water in cisterns. Cistern readings measured by *Holländer* (source: [4])

Associate professor, Priv. Doz. Dr rer. nat. Reinhard Holländer

As microbiologist and hygienist, *Reinhard Holländer* directed the Institute for General Hygiene, Hospital Hygiene and Environmental Hygiene at Klinikum Bremen Mitte (Bremen Hospital, central district). He is motivated both personally and professionally to discuss health issues in connection with rainwater utilisation in various publications [4] and by giving numerous talks. Priv. Doz. Dr *Holländer* received his PhD in 1976 and completed his habilitation in microbiology in 1984.

Rainwater utilisation and hygiene

"In our high-tech society, the use of rainwater is somewhat of an anachronism. But there are many reasons why this technology, which has been forgotten in so many places, should be revived to enable natural water resources to be utilised. Arguments are often raised with concerns about the safety of rainwater with regard to our health. This stems from a historic fear of water-related diseases such as typhus, cholera or dysentery. In all likelihood, this kind of argument is frequently used to protect commercial interests. However, we have no need to worry about the kind of water-related diseases that troubled previous centuries, because of the high standards of hygiene in place in today's society, in which drinking water systems are strictly separated from drainage systems (**Figure 5, 6, 7**). When a rainwater storage system is properly installed and used in accordance with DIN 1989, fears of health risks are not justified, as the thousands of these systems and their users prove on a daily basis." [5].

Table 1: Rainwater technology project data

1st construction phase 1995	
Tank volume	1 x 29 400 l
Application: watering, pond, fountain	250 m³/year
Maintenance outlay	1 hour/month
Operating costs	approx. € 100/year
2nd and 3rd construction phases 2001/2008	
Tank volume, extended by	8 x 2000 l
Application: cooling water circuit for sterilisation system	
Watering, pond, flushing of 111 toilets	2900m³/year
Maintenance	2 hours/month
Operating costs	approx. € 500/year

Planning and implementation:

System technology planning: Ing. Gemeinschaft Libbach & Janssen, Eschborn
Filter technology manufacturer: Wisy AG, Kefenrod
Assembly: *Hermann Horn*, Wildeck-Bosserode

2010 with a view to future expansion and additional building projects at the Bad Hersfeld Clinic: His evaluation revealed investment costs of € 21 000 (€ 71 100 minus the subsidy of € 50 100 in 1995 that was funded by the State of Hesse). Taking the costs saved in 2009, amounting to € 13 728, into consideration, the amortisation period was less than two years. This also includes investments for spare parts and increasing operating costs. Projected over an operating period of 20 years, the clinic will save a sum of € 274 554.

Plans have now been formed to expand the system by another 100 toilets in new buildings and building conversions. The need for water will be balanced to suit the water yield by enlarging the storage tanks by a further 10 m³. *Kohlrenken* estimated targeted savings of an additional € 5373 per year, which, in 20 years will amount to € 107 465. Investments will cost between € 31 500 and € 58 000, producing an amortisation period of 6–11 years.

Bacteria don't stand a chance

The designated use determines the level of quality required in process water. There are no limits set for water used to water gardens, flush toilets and wash clothes. The quality of cistern water is sufficient providing the system has been built according to the standard of technology that complies with DIN 1989. This directive calls for an absolute separation of drinking water and rainwater installations. Treatment or disinfection of collected rainwater is not desirable for ecological and economic reasons, and is normally not even necessary. Natural processes and limited nutrient availability mean that bacteria accessing cisterns only exist for a short period of time. Concentrations measured were clearly below the levels stipulated for water in bathing areas [6].

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