Water reuse in healthcare

Healthcare organizations, major consumers of water, are considering treatment and reuse strategies as water shortages persist in some regions. Authors **Christy Love** and **Peter Haase** discuss the water quality, regulatory, and treatment issues involved in the reuse of treated hospital effluent.

The healthcare industry – more specifically, hospitals – will likely face mounting pressure around water issues in the years to come. The pressure will come on two fronts: first, healthcare facilities use a significant amount of water in their operations, at a time when constraints on the resource are being demonstrated by water shortages and persistent droughts in many regions, and when water and sewer costs are increasing. Second, hospitals face a growing awareness among communities and policymakers about the human and environmental health effects of pharmaceuticals and other contaminants of concern in the water supply – meaning that hospitals may be compelled to address the content and quality of their effluent.

Increasing consumption costs and a desire to mitigate risk are leading some healthcare organizations to implement or seriously consider water treatment and reuse strategies as part of a comprehensive water management strategy.

Why reuse?

American hospitals use a lot of water. The average hospital in the United States uses in the range of 2,157 liters (570 gallons) of water per bed per day, while the average European hospital uses about 500 to 1,000 liters (132 to 264 gallons) per bed per day.

According to the Massachusetts Water Authority, hospitals routinely rank in the top ten water consumers in any given US community. That's not surprising, given that hospitals must use water throughout their operations on a constant basis, including in food service, laundries, cooling towers, boilers, image processing for x-rays, process water for vacuum systems, and sterilization, as well as for patient, staff, and facility hygiene.

While still relatively small compared to energy, utility costs for water are increasing rapidly across the country. Many regions have seen increases of eight to ten percent per year for the past several years. That can mean an increase in water and sewer utility bills of as much as US$100,000 a year for a single large hospital.

Consumption is just one facet of hospital-related water issues. There is also a growing awareness of the presence and potentially harmful effects of pharmaceuticals and other contaminants of emerging concern in waterways and drinking water. In 2004 and 2007, the US Geological Survey detected the presence of numerous pharmaceuticals at various drinking water sites across the country, and in 2008 the Associated Press reported the presence of dozens more, including antibiotics and an anti-depressant. While those pharmaceuticals are present at low levels, scientists have detected adverse health impacts on wildlife from long-term, low-level exposure. It would not be surprising to discover health effects on humans, as well.

Today, federal and state regulators are examining more closely the levels of pharmaceutical compounds and other persistent contaminants in US drinking water, making future regulation of hospital discharge more likely, as the responsibility for wastewater is shifted upstream from wastewater treatment plants to the source of pollution.

Composition of hospital wastewater

Hospital wastewater is similar in character to a moderate-strength domestic wastewater, with a relatively high concentration of soluble and suspended organic load, nutrients, pathogens, and pharmaceutical compounds. The most significant chemicals potentially present in hospital wastewater are antibiotics, cystostatic agents, anaesthetics, disinfectants, platinum, mercury, and iodinated x-ray contrast media. Other substances that have been detected in hospital effluents include lipid regulators, analgesics, antibiotics, antidepressants, antiepileptics, antineoplastics, anitpyretics, antirheumatics, estrogens, and other pharmaceutical compounds.

Besides recalcitrant and potent chemicals, hospitals discharge a wide variety of potentially pathogenic papagules, including antibiotic-resistant bacteria and viruses. Table 1 summarizes typical characteristics of hospital wastewater.

For the most part, hospital water discharges are co-treated with domestic wastewater, resulting in a reduction of recalcitrant compound concentrations in the final effluent due to water dilution. However, many pharmaceutical compounds resist breakdown through conventional treatment processes. Focusing on on-site treatment, therefore, generates a tremendous opportunity for water reuse, while simultaneously reducing the effect of pharmaceuticals on local waterways, wildlife, and the surrounding community.

Uncertain regulatory framework

There is currently limited regulation of hospital wastewater discharges, and many of the contaminants discharged from hospitals have been largely unregulated to date. However,

Lucile Packard Children's Hospital in Palo Alto, California, is collecting, storing, and using rainwater for irrigation onsite. Rendering courtesy of HGA Architect and Engineers

Answering those questions will enable hospitals to more fully and confidently reuse their water resources, as well as to anticipate solutions to future regulatory requirements.

Table 1. Typical characteristics of hospital wastewater

Pollutant	Hospital Wastewater	Domestic Wastewater
BOD (mg/L)	240 +/- 82	210-400
COD (mg/L)	480 +/- 125	300-500
COD filtered (mg/L)	331 +/- 54	200-400
TSS (mg/L)	227 +/- 57	210-400
NH4 (mg/L)	42 +/- 9	45-65
Total Phosphorus (mg/L)	6 +/- 2	1.5 – 5
E. coli (CFU/100ml)	$2x10^5$ - $2x10^6$	$2x10^5$ - $2x10^6$
Individual antibiotic concentration (μg/L) (Pauwels 2006)	2-83 measured; 5-50 estimated	< LOD- 0.6, 1.7, 6, 51
Individual therapeutics concentration (μg/L) (Pauwels 2006)	5-50 estimated	< LOD - 5.7
Estrogens (ng E2-eq/L) (Pauwels 2006)	>100	20-100

LOD = Limit of Detection
Source: The Treatment of Hospital Wastewater: An Appraisal, B.Pauwels and W. Verstraete, 2006 and Fall Creek Engineering/Aqualogic

current federal and state laws do provide a legal framework that could allow local cities and towns to regulate those discharges through their existing pretreatment programs. (The US Environmental Protection Agency (USEPA) has also released draft Best Management Practices to eliminate the common practice of hospitals flushing unused pharmaceuticals and to address the problem from the source side.[1])

The National Pretreatment Program (NPP) was developed by the USEPA to control the discharge of pollutants from publicly owned treatment works (POTW) or municipal treatment facilities [2]. To meet the requirements of the program, the USEPA developed the General Pretreatment Regulations for Existing and New Sources of Pollution [Title 40, Code of Federal Regulations (CFR) Part 403]. The Pretreatment Regulations require each state to adopt water quality standards by designating water uses to be protected and by adopting water quality criteria that protect these designated uses.

The General Pretreatment Regulations require the following:

- POTWs that are developing pretreatment programs must develop and enforce specific limits on prohibited discharges, or demonstrate that the limits are not necessary [40 CFR 403.5(0(4)].
- POTWs that have approved pretreatment programs must continue to develop and revise local limits as necessary [40 CFR 403.5(c)(1)].
- POTWs must develop specific local limits if pollutants from non-domestic sources result in interference or pass through and such occurrences are likely to recur [40 CFR 403.5(c)(2)].

The important takeaway from the current framework is that POTWs have the authority to regulate discharges from hospitals, if they find that these discharges result in interferences and/or pass through the POTW and pose a threat to water quality.

Treatment comparison

Off-site treatment at a wastewater facility: Treating hospital wastewater through municipal wastewater treatment facilities is neither currently environmentally adequate nor technically viable to meet state and federal requirements. To do so would require that the treatment plants implement an aggressive source control program and install advanced treatment processes to remove pharmaceutical compounds. That is a costly option for municipalities, which would have to pass on the added costs to ratepayers. That scenario also places the environmental, economic, and regulatory burden on local governments.

On-site pre-treatment: A second option would be an on-site pre-treatment system to reduce the concentration of pharmaceutical compounds before hospital effluent is discharged to the municipal sewer, where it would receive final treatment. Under that scenario, both the hospital and the local municipality would share the environmental, economic, and regulatory burden, although the site would not maximize its opportunity for beneficial reuse.

On-site treatment and reuse: Comprehensive on-site treatment, reuse, and/or disposal provides the highest efficiency and environmental benefits because a small-scale, effective treatment system will likely be more ecological and cost-effective than a larger-scale, alternative technology that would produce a lesser effect on the diluted hospital emissions. That option shifts the environmental, financial, and economic burden to the hospital, but also maximizes the benefit of on-site reuse. Any on-site treatment program should be paired with a rigorous source-control program to eliminate deliberate pharmaceutical flushing and to optimize treatment effectiveness.

Current precedents

No hospital facilities in the US treat and reuse their wastewater onsite. However, the Oregon Health Sciences University Center for Health and Healing (CHH) – located in Portland, Oregon, and occupied in 2006 – is an academic medical center that, as part of its commitment to develop an environmentally responsible building, installed an on-site membrane bioreactor (MBR) system to treat 95,000 to 121,000 liters (25,000 to 32,000 gallons) of water per day. The plant is a complex system that recycles the building's entire sanitary waste output and reuses about 65 percent for toilet flushing, cooling tower makeup, and irrigation. It does not monitor the removal of pharmaceuticals or other persistent chemicals; however, it does have strict protocols in place that restrict chemical disposal to the sanitary systems.

Cautious progress is being made by hospitals that appreciate the value of water, but also recognize their critical function of restoring and protecting health and minimizing exposure to potential health risks (e.g.. using recycled water for toilets that may come into contact with immune-compromised patients). For example, several new hospitals are collecting, storing, and using rainwater for irrigation, including Lucile Packard Children's Hospital in Palo Alto, California; the Eskenazi Health complex in Indianapolis, Illinois; and the Kaiser Westside Medical Center in Portland, Oregon. The authors of this article are also working to develop a test bed facility to test and validate the efficacy of on-site treatment systems for efficient pollutant removal and reuse opportunities.

Australian reuse guidelines

On the governance side, the Victorian Government Department of Health in Australia released the Guidelines for Water Reuse and Recycling in Victorian Health Care Facilities in 2009. The guidelines support the reuse of recycled water for non-potable uses and outline a recommended risk management approach for hospitals to take a pro-active approach to sustainability while pursuing the lowest risk options. The lowest risk options result in the lowest chance of compromising the health of patients and other users, while also minimizing energy and resource consumption.

Because hospitals are high water consumers with a vested interest in the health of their users and the environment, on-site wastewater treatment and reuse presents an excellent opportunity to both save operating costs and protect communities. However, additional research is needed to understand the extent and concentration of contaminants in hospital wastewater, as well as the most effective methods of treating and monitoring these contaminants. Answering those questions will enable hospitals to more fully and confidently reuse their water resources, as well as to anticipate solutions to future regulatory requirements.

Authors' Note

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Peter Haase is a principal engineer at Fall Creek Engineer and CEO/CFA Acqualogic. His work focuses on decentralized and advanced wastewater treatment systems and has been partnering with M+NLB to develop the test bed project to treat and reuse hospital wastewater.

Footnotes:
1. http://water.epa.gov/scitech/wastetech/guide/upload/unuseddraft.pdf
2. The statutory authority for the NPP lies in the Federal Water Pollution Control Act of 1977, which was amended by Congress in 1977 and renamed the Clean Water Act (CWA). Under Section 307(b) of the CWA, the USEPA must develop "pretreatment Standard" that prevents the discharge of pollutants that pass through, interfere with, or otherwise are incompatible with POTWs.