The end of the road for Big Pipe?

The concept of centralized wastewater treatment is being challenged. The alternative – decentralization – is growing in importance, but will not provide a universal solution, as Gord Cope discovers.

Decentralized wastewater systems – the facts

- Centralized wastewater systems use large-scale gravity pipes to collect wastewater from as great a number of communities and catchment basins as possible. Large plants can handle over 1 million m^3/d.
- Decentralized wastewater systems operate using a large number of smaller-scale plants, ranging from 100,000m^3/d to under 500m^3/d. These can be installed in office towers, shopping malls and apartment buildings.
- Centralized systems offer economies of scale, both in terms of capital costs and operating costs.
- Decentralizing allows closer matching of capacity to actual growth in demand, limits water losses from a given catchment area, generates energy savings and lower sewer pipe costs, and allows greater levels of conservation and reuse.
- Membrane bioreactor (MBR) systems, in which wastewater is treated with both microfiltration and aerobic treatment, are proving particularly adaptable to the non-municipal market.
- An MBR capable of handling a 150-unit apartment block costs about $500,000.
- The MBR market in the US was valued at $216 million in 2006, and will to rise to $363 million by 2010.

The Brontosaurus was the largest animal ever to roam the earth. Weighing some 25 tonnes and growing to a length of 75 feet, this Goliath dominated the landscape 150 million years ago, until changes in climate and the emergence of tiny, fleet competitors undercut its rule.

Likewise, in the world of wastewater treatment, the centralized plant has held sway for at least the last century. During the past 100 years, immense facilities capable of handling millions of cubic metres of effluent per day have provided the most efficient, economical and safe way of treating liquid effluent from major cities. But now, just like the dinosaur, their dominance may be in jeopardy due to the emergence of decentralized wastewater treatment plants. Are the days of mega-plants numbered?

Paul O'Callaghan is an environmental scientist with consultancy O2 Environmental in Vancouver, and chairs the British Columbia Water and Wastewater Association's technical committee. "In the past, bigger was better," says O'Callaghan. "You could build a plant with twice the capacity, but not twice the cost."

Centralized systems use large-scale gravity pipes to collect wastewater from as great a number of communities and catchment basins as feasibly possible. Decentralized wastewater management, on the other hand, encourages the use of satellite and catchment-based treatment options. Instead of building one large plant to handle one million m^3/d, for instance, a municipality can construct ten 100,000m^3/d plants, each one close to a specific wastewater source. "It is gaining attention as a more sustainable and cost-effective method of managing water resources, and is challenging the paradigm that 'Big Pipe' is the only viable option," says O'Callaghan.

While working in Dublin, Ireland, O'Callaghan saw first-hand how centralized networks could create problems. "When a municipality plans for infrastructure, they typically use a 20-year horizon," he notes. "They try to predict what the population will do, what the climate will be doing, what the economy will be doing. But no one foresaw the Celtic tiger years in Ireland, which caused huge economic and population growth in Dublin." The Ringsend treatment plant, which had a design capacity of 1.7 million population equivalents (p.e.) and a design horizon of 20 years, was at capacity almost as soon as it opened in 1999. "Dublin currently has infrastructure bottlenecks; there's a moratorium on any further development because the sanitary system couldn't handle it."

Decentralizing has several benefits. The smaller unit size of a decentralized system allows closer matching of capacity to actual growth in demand, for instance. "Decentralized capacity can be built cluster-by-cluster, in a 'just-in-time' fashion," says O'Callaghan. This provides a number of important benefits, including the deferral of capital costs for future capacity, faster implementation and smaller feed pipes.

Decentralized systems can avoid the kind of damage that centralized systems typically cause to the local environment. "By carrying water out from one catchment to another, centralized systems can draw down the local resource, and there is less water available to seep into the groundwater system," says O'Callaghan. "When large pipes are under gravity drainage, groundwater leaks in, which not only contributes to hydraulic overloading at the treatment plant, but also takes water out of the catchment which would otherwise replenish groundwater aquifers and feed streams and rivers."

Decentralized systems also benefit conservation programmes. "When you have severe hosepipe bans, you don't get sufficient carrying volume in gravity pipes," says O'Callaghan. "With closed pressure pipes, which are more common in decentralized systems, you can accommodate conservation without the problem of sewers becoming blocked due

to inadequate flushing volume."

Additionally, decentralization limits the potential for catastrophic failure. "A number of wastewater treatment plants were destroyed by Hurricane Katrina," says O'Callaghan. "But you can also have a mechanical failure within the plant; inlet screens get blocked and fail, and you have wastewater backup and overflows. At a large, centralized treatment plant, when things go wrong, they can go wrong in a big way."

Objections to decentralized systems generally centre on increased costs due to loss of economies of scale. Dr Val Frenkel is the director of membrane technologies at Kennedy/Jenks, a major water consultancy based in San Francisco, and has been designing wastewater systems around the world for over two decades. "Decentralization can have many advantages, including reliability and flexibility of operations," he notes. "But you can hire and train labour much more cheaply for a centralized operation, and operational costs are lower."

O'Callaghan agrees that the capital and operating costs for decentralized systems are higher, but argues that other factors more than outweigh these disadvantages. "Given that collection system costs can be 80% or more of total systems costs, collection diseconomies of scale can overwhelm treatment economies of scale, resulting in decentralized systems being the more economical choice."

Another objection to decentralized systems relates to quality concerns. "Historically, smaller plants are less capable of producing high quality effluent versus large plants," says O'Callaghan. "But there have been advances in technology that make smaller plants more reliable and capable of high standards."

Waste not, want not

Many regions throughout the world suffer from a shortage of potable water, either due to drought conditions, over-exploited aquifers or heavy agricultural use. Efforts to relieve shortages often involve expensive diversion projects or desalination. One grossly underused resource is wastewater, which can be reclaimed for non-potable uses at a fraction of the cost of fresh potable water. The AWWA and the Water Environment Federation examined the potential, and recently published a book called *Using Reclaimed Water to Augment Potable Resources*.

"It concluded that it is very valuable to get water from industrial and municipal sources," says Frenkel, one of the authors. "There are 40 projects around North America where municipalities are reusing water, but less than 1% of water in North America is recycled now. We could do 100%."

Decentralization holds one major advantage over centralized systems in that it is more amenable to water reuse. "Under the decentralized management concept, effluent is produced at many points throughout the overall service area, potentially closer to points of reuse," says O'Callaghan. Pipes carrying grey water for park and golf course irrigation, for instance, can be shorter and smaller in diameter, and cheaper to install and maintain. "This practice can also reduce water treatment pumping and storage costs, and can forestall expansions of water treatment and storage facilities."

While utilities are experimenting with reuse on a municipal scale, there is another immense potential market on the horizon: non-municipal wastewater treatment. Laura Shenkar is a principal with the Artemis Project, a consultancy engaged in promoting the development of systems that can be used in apartment blocks, retail developments and office towers. "There are 54,000 utilities in the US. But when you look at institutional and commercial entities, from hospitals and airports to Wal-Mart and large office buildings, there are several times more entities," she says. "That's a juicy part of the water management market."

Already, wastewater equipment manufacturers are designing equipment with just that in mind. Membrane bioreactor (MBR) systems, in which wastewater is treated with both microfiltration and aerobic treatment, are proving particularly adaptable to the non-municipal market. In addition to having a compact footprint and being scalable to smaller applications, they are highly suited to automation and require relatively little maintenance. Major membrane suppliers include Mitsubishi, GE/Zenon, Siemens/Memcor and Kubota, while major OEMs include Siemens and GE. "Demand is good," says Andy Zaske, product line general manager for engineered systems at GE Water & Process Technologies. "We have three main areas of MBR business: government, industrial wastewater, and industrial-municipal tertiary treatment for reuse for irrigation. They're about one third each in terms of projects."

Pennant Hills Golf Club, in New South Wales, Australia, is an example of how water shortage is driving the trend towards decentralization. After a decade of drought in the Greater Sydney area, the golf club's water supplies were restricted to 605m^3/d, well below their summer irrigation needs. In order to keep the course green, they contracted with the city to siphon off a portion of the raw sewage flowing in a municipal sewer line beneath their property and clean it up sufficiently for irrigation purposes. GE installed a 650m^3/d Z-MOD system that combined biological wastewater treatment with hollow fibre ultrafiltration membranes to remove nutrients and suspended particles. The output was then treated with UV and chlorine before entering the irrigation system. In the end, the golf course dramatically reduced its potable water usage, saving the city 274m^3/d.

In addition to water shortage, decentralization is also being driven by economic growth in developing countries. "There's lots of interest globally, outside of North America," says Zaske. "As you look at emerging markets, often expansion is outpacing the government's ability to meet infrastructure demands. We have different models of our Z-MOD platform for India, China and the Middle East."

Obstacles

Several significant obstacles currently prevent the widespread adoption of non-municipal decentralized wastewater systems, one of the largest being capital costs. Val Frenkel explains the economics: "A 150-unit condo complex would use an MBR designed as a 'scalping facility'. About 1% of wastewater is sludge, but operating costs to get rid of that sludge amount to 50% [of the total]. A scalping facility separates out the sludge and sends it on to the municipal wastewater treatment plant. The other 99% is treated to grey water standards." Scalping facilities are cheap to run; operating costs work out to about $0.20/m^3, but they can also cost around $500,000 to install – a major stumbling block.

"Decentralized units in condos are practical now," says Frenkel, "but the developer has no driver to do it; it's easier for them to pay the connection fee and let the condo owners pay the treatment costs."

The economics are evolving, however, leading to more opportunities for private wastewater treatment systems. "The developer of a large shopping mall near São Paulo in Brazil wanted to be independent of the municipal system," says O'Callaghan. "There were cost issues, with the municipality wanting to charge around $5.00/m^3 for combined water supply and treatment. We designed a system with a groundwater well for source and chlorination for treatment. They also

wanted to take the wastewater and treat it for reuse. It had the capacity to treat 2,000 p.e., or 500m³/d." The wastewater treatment module used a Vertreat system (patented by NORAM Engineering and Constructors of Vancouver), which is a deep shaft process, about 100 ft deep and 2 ft in diameter, with a steel casing. Air is blown down with a compressor to aerate the water. The water comes back up, the sludge is separated and the water is disinfected using UV. The grey water, with 10mg/l of BOD and 10mg/l of TSS, is used for flushing toilets and irrigating the grounds. The system cost under $1 million.

"It is easier to operate than an MBR and you don't need to backwash and clean it," says O'Callaghan. "Non-specialists can operate and maintain it. You don't need a full-time attendant, as there is no day-to-day maintenance."

According to O'Callaghan, there are now over 200 Vertreat facilities in place worldwide. "You can scale it up; there is a plant in China designed for 100,000 p.e."

Quality of output is another concern. One of the dangers of onsite wastewater processing and water recycling is that contaminant spikes can occur, even with state-of-the-art technologies, as a result of minor operational changes or varying weather conditions. "You can have spikes in *E. coli* counts with no warning," says Shenkar. Authorities are concerned about turning over constant human supervision (typical at centralized plants) to electronic monitors at private facilities that might not be able to catch unusual spikes. "We do not have real-time monitoring for key indicators yet," says Shenkar. "We don't have idiot-proof systems yet – that's the real problem."

GE maintains that monitoring systems can be made sufficiently advanced to handle spikes, but that sophisticated devices then create their own problems. "You can go two ways with monitors – it's a balancing act," says Zaske. "You can make them simple, with a standardized design that is easy to operate and maintain, or you can make them complex, but if you add too much, you can get false readings." GE and other manufacturers are now promoting connectivity of systems through the internet to help automated systems operate safely and effectively. "We now have an online tracking system that allows us to upload information and help the customer troubleshoot," says Zaske.

Permitting is another major obstacle. "We discover some new problem in water all the time," says Frenkel. "Cryptosporidium, endocrine disruptors – we'll find other things in the future. Regulators think: How can we approve [non-municipal installations] if we don't have standards to examine and control that water? No municipality wants to take the responsibility for the liability."

Flush with success

The future for decentralized wastewater systems looks bright. One UK consultancy estimated that the MBR market in the US alone was valued at $216 million in 2006, and will to rise to $363 million by 2010. The rapid growth in the market will be propelled by a number of factors, including energy conservation. "In California, we use over 19% of our electricity to transport, purify and dispose of water," says Shenkar. "We did a study in Chino, California, that showed that onsite water reuse could save 85% of the energy used to transport, process and dispose water to a commercial site. In this case, Southern California could save more energy with decentralized water management than by putting solar panels on every roof of every commercial location."

Scarcity issues will force reuse through legislation, and thus decentralization, predicts O'Callaghan. "The Sunshine Belt can reduce usage, but at some point you have to shut up shop. We'll see decentralized systems and reuse becoming more and more common at golf courses, industrial plants, hotels and resorts."

The growth of business in developing countries will also help. "MBR has advantages in regions where expansion of the economy is outpacing a government's ability to accommodate growth," says Zaske.

But the dinosaur of centralization should not worry about succumbing to decentralized wastewater treatment – at least not yet. "In order for decentralization to work on such a level, you need wide public acceptance, legislative drivers, government incentives, and clear regulations regarding standards, usage, equipment and liability," says Frenkel. "We'll get there slowly in some places, and a lot faster in others, but we're all going to be reusing water eventually."