WASTEWATER MANAGEMENT

Decentralized and Distributed Wastewater Management

The time has come to rethink our approach to effective wastewater management.

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ABSTRACT

For most of the past 100 years, the predominant model for wastewater management has been the centralized wastewater treatment (CWWT) facility. However, as our communities are embracing the need for greater sustainability, infrastructure security, and resilience, it may be time to evaluate and implement a more local alternative: a distributed network of decentralized wastewater treatment (DWWT) and resource recovery facilities. This paper outlines the benefits and potential applications of DWWT facilities, and identifies challenges and best practices for deploying a decentralized treatment model.

INTRODUCTION

For most of the past 100 years, the predominant model for wastewater management has been the **centralized wastewater treatment (CWWT)** facility. In most developed economies, the benefits of such professional and effective sanitation have been enormous. However, as our communities are embracing the need for greater sustainability, infrastructure security, and resilience, it may be time to evaluate and implement a more local alternative: a distributed network of **decentralized wastewater treatment (DWWT)** and resource recovery facilities.

CENTRALIZED WASTEWATER TREATMENT

While the benefits of CWWT facilities are significant, there are inherent weaknesses:

- Typically servicing a large catchment area, CWWT requires an extensive network of large sewer lines that are costly to install and maintain, and susceptible to increasing levels of leakage as they age.
- Typically servicing myriad residential, commercial, institutional, and industrial clients, a highly complex stream of raw sewage is discharged into an end-of-pipe treatment facility, where it may be extremely difficult to recover resources (including water), and which may be many kilometers from potential water reuse targets anyway.
    - In the USA, 32 billion gallons of municipal wastewater are produced every day, but less than 10 per cent of that is intentionally reused.[1]
    - Across most developed economies, the existing CWWT facilities were designed and installed long before climate change and the need for resource recovery were important design considerations.
- Traditionally, CWWT facilities tend to be designed for a 25+ year horizon. This may often over-estimate or under-estimate the population growth within the community, and often places a significant financial burden on the community.
- By its nature, the CWWT facility is a single point of vulnerability that could bring down all sanitation services to a large part of the community should the operations be compromised by extreme weather events, power outages, operator error, physical or cyber terrorism,[2] military conflict, etc…
- Owing to its size and embedded cost, within the CWWT there is a level of inertia in terms of ability to evaluate and implement newer, more advanced treatment technologies, beyond initial piloting activity.

DECENTRALIZED WASTEWATER TREATMENT

DWWT, on the other hand, refers to the practice of locating treatment equipment and processes close to the point of wastewater generation, be it:

- Residential developments, including apartment buildings and small clusters of homes, up to the size of a rural village.
- Commercial and institutional facilities such as office buildings, shopping centres, schools, hotels

and resorts, sports facilities, prisons, highway rest stops, etc…

- Light industrial facilities such as craft breweries and wineries, artisanal cheese producers, and similar (although these may also be described as pre-treatment operations when discharging into a municipal sewer system).

Benefits of DWWT

The benefits of decentralized treatment, as described by a growing number of proponents, include:

- The overall vulnerability to disruptions in service from natural or man-made events would be limited to a relatively small group of clients, or mitigated completely by shared service mechanisms. The system could also be brought back online faster with less cost or impact.
    - » Superstorm Sandy in 2012 proved the resilience of distributed systems. The New York/New Jersey area was hit hard, flooding and knocking out many of the low-lying sewage treatment systems. But the dozens of onsite, distributed wastewater recycling systems in the region were all back up and running on generators 24 hours after the storm.[3]
- Grey and black water discharges can be treated at (or adjacent to) the point of generation for immediate reuse within or around the development for a range of non-potable applications. This significantly reduces the overall water footprint of the community.
- Community development can progress faster and at a lower capital outlay.
    - » Development does not have to wait until connections are made to an existing sewer line (if one exists), or until new sewer services are run to the area.
    - » Smaller, local service area facilities can be constructed quickly and at lower cost with a shorter horizon, then expanded in modular increments to match development as required.
    - » Smaller diameter and shorter sewer lines would reduce the cost of deployment and would be better tailored to actual wastewater flows to the treatment works.
- Today, many DWWT systems are modular and standardized around a range of flow-based sizes, with resulting benefits including:
    - » Lower upfront CAPEX with the ability to defer downstream expansion costs until supported by revenue from development charges.
    - » Faster and simpler construction.
    - » Smaller mechanical equipment, with the possibility of sharing spares and stand-by units with neighbouring DWWT facilities.
- The family of pre-engineered decentralized technologies includes:
    - » Extended Aeration (EA)
    - » Sequential Batch Treatment (SBR)
    - » Membrane BioReactor (MBR)
    - » Moving Bed BioReactor (MBBR)
- The smaller decentralized catchment area would enhance the opportunity to precisely tailor networks to anticipate local peri-urban development.

- Commercial and light industrial water consumers and wastewater generators may be more easily integrated into the local service area.
    - » A holistic model for the entire water cycle within a small, local area can optimize water balancing within the community and lower the overall water footprint.
- Billions of people around the world lack access to safe and effective sanitation, let alone sewage treatment, with significant health, economic, social, and political consequences. In these areas, the rapid deployment of smaller, affordable DWWT systems offers the only viable solution to approaching the United Nation's Strategic Development Goal (SDG) 6: "By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations".[4]

Challenges of DWWT

Balancing these potential benefits, arguments against radical decentralization have held sway for many decades, including:

- In the past, small privately-owned and -operated plants have tended to be staffed with less qualified operators in some areas.
- Multiple small, independent plants across a community may create more complex overall control issues.
- Advanced treatment technologies may be more affordable and manageable at a large, centralized facility.
- Some resource recovery technologies have a Return-on-Investment threshold that favours larger treatment facilities.
- Poorly designed and constructed decentralized plants can be an expensive burden to the community if abandoned by an independent operator.
- Significantly, an entire design community, product and service supply chain and regulatory approvals mechanism has evolved over many decades around the large, CWWT utility.

The Case for DWWT

Despite these arguments, DWWT systems have recently improved with advances in product and process technology, remote monitoring, and systems management. There is also an urgent global need to address sustainability and resilience. As such, it may be time for the water sector to look at emulating the successful migration away from the monolithic utility model that we have seen happen within the energy and communications sectors.

Today, we no longer require the technical, physical, and financial mass of a CWWT facility to ensure our communities have reliable, effective, and affordable sanitation. Rather, with easy access to advanced technologies from a global supply network, and by leveraging the developments in communications and inter-connectivity, we can access these benefits while enhancing our water security and resource optimization.

Best Practices for DWWT Deployment

DWWT solutions offer many potential benefits, especially for:

- Communities considering new greenfield wastewater treatment facilities.
- Upgrading existing decentralized municipal treatment works to meet new loading and/or effluent discharge criteria.
- Centralized utilities looking to extend coverage into an expanded urban or peri-urban envelop.

However, in order to extract the maximum benefit, the deployment of DWWT infrastructure should be carefully planned, coordinated, and executed according to best practices:

- Borrowing from the IT sector, regional utilities may consider exploring **Distributed Decentralized Wastewater Treatment (D2WWT)** wherein a network of DWWT facilities are owned, operated & managed, in a hub & spoke arrangement, by a central entity with:
  - » Common, standardized designs, construction, and operating parameters.
  - » Interchangeability of parts.
  - » Load sharing where interconnection with small diameter, pressure lines is practical and beneficial.
  - » Centralized monitoring, operations management, and back-office services.
- Segregate sanitary and process (industrial) streams and only allow process streams that have been fully pretreated to typical sanitary wastewater characteristics into any community treatment works.
- Require all industrial clients to treat all internal wastewater streams to a quality level suitable for direct inhouse reuse, and to transfer any “non-treatable” effluent to an offsite, industrial wastewater management facility.
- Establish a realistic set of final effluent quality criteria to be achieved by any DWWT facility within the catchment area.
- For any single onsite DWWT facility or for any community network of DWWT facilities, develop a water footprint reduction strategy that maximizes onsite and/or local water reuse.
- For any network of DWWT facilities where each individual site may be too small to adopt resource recovery technologies (such as phosphorus recovery), consider establishing a hub & spoke model, wherein a centralized recovery facility can be established to aggregate feed from the treatment nodes for cost-effective recovery.
- For any DWWT facility external to a centrally managed network, require all facilities to have:
  - » An operating system that can be continually monitored, or will send out alerts when key functional parameters are exceeded.
  - » An onsite stock of spares for all key mechanical, instrumentation, or other process-critical equipment.
  - » A cloud-based log of required analytical data (as required by the system vendor), and permit criteria fully accessible by the permitting agency.
  - » An Operations and Maintenance (O&M) protocol and log that reflects the base requirements of the system vendor, updated annually to reflect application- or site-specific conditions.

CONCLUSION

In some cases, the advantages and benefits of the CWWT facility will continue to outweigh any other alternatives. But for many communities and applications, advances in technologies, processes, and products have now overcome many of the barriers or objections to the deployment of widespread DWWT systems. These systems represent a viable option to address our growing concerns over water scarcity, infrastructure security and resilience, and the urgent need to provide access to safe and effective sanitation for the billions of people around the world without any infrastructure.

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