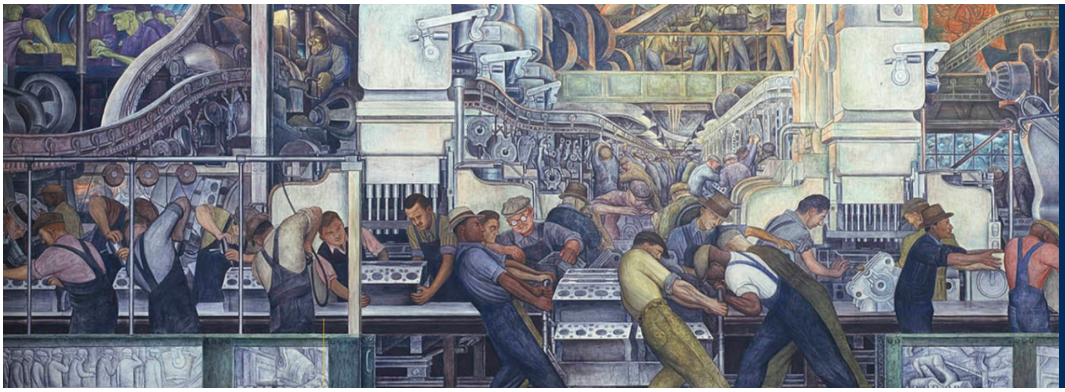

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Decentralized Wastewater Treatment in Detroit

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EXECUTIVE SUMMARY

Decentralized wastewater treatment is the future of wastewater treatment. In developing countries without sophisticated wastewater infrastructure, it is the design of choice since it has lower capital costs, protects the local environment, and incentivizes water re-use. Though promising, technological limitations and 'cultural inertia' are currently the main drawback of decentralized wastewater treatment in developed countries. Centralized wastewater plants are the predominant technology in the U.S. Implementing decentralized treatment lowers the value of the existing infrastructure and increases the relative cost of new facilities since there are already functioning treatment plants. Despite these roadblocks, significant technological innovations and the increasing risks of climate change are showing that decentralized wastewater treatment is necessary for the 21st century. But since widespread adoption of decentralized wastewater treatment is decades away, there are alternative methods to reducing the cost of wastewater treatment for disadvantaged communities in the U.S.

BACKGROUND

There have only been two primary methods for treating wastewater in the United States: (i) centralized using large-scale treatment plants and (ii) decentralized using septic tanks. Decentralized wastewater treatment plants (DWTPs) are common in rural areas, where the low population density makes a central treatment solution prohibitively expensive.[1] Analogously, centralized wastewater treatment plants (CWTPs) are found in large or urban municipalities, such as Detroit. Since the purpose of this report is on active wastewater treatment, the report will not include any technical information on septic tanks, which are passive. Any discussion of decentralized plants will focus on small scale wastewater treatment that compliments a larger system.

Wastewater Treatment Process

The treatment processes are similar for centralized and decentralized plants. In both, there are 5 key steps:

1. Collection: Sewage, rainwater, run-off, or any other source of contaminated water is fed to a centralized location
2. Screening: Large objects (e.g., rags, napkins, etc.) are removed using large filters
3. Primary treatment: Separation of organic, solid waste by sedimentation
4. Secondary treatment: Active microorganisms (i.e., CAS) consume small organic particles
5. Disinfection: Chemical additives kill any remaining microorganisms

The treated effluent is then discharged to the local environment, completing the process. Wastewater treatment plants also generate revenue by selling high value byproducts – methane and fertilizer – that are formed during the primary and secondary treatment phases.

The main difference in decentralized wastewater treatment is that there is a greater variability in the flow of wastewater into the system since the plants service a smaller area.[2] This places a greater burden on engineers of these systems to develop specialized operations to deal with variable flow issues.

Wastewater Treatment in Urban Municipalities

Centralized wastewater treatment is the predominant method for urban areas because the economies of scale favor treating wastewater at a single, large site. The large piping infrastructure to transport water, the main cost barrier in rural areas, is more economically favorable if the piping services more people. Decentralized plants are extremely uncommon in developed countries but are increasingly popular in developing countries that don't yet have sophisticated wastewater treatment infrastructure.[3–5] In developed countries, such as the United States, where centralized wastewater infrastructure is already in place, decentralized treatment plants are left to rural communities. It is highly unlikely decentralized wastewater plants will ever replace the existing centralized plants in urban communities, but there is immense interest in their use to supplement centralized plants.

CENTRALIZED WASTEWATER TREATMENT

Benefits

Centralized wastewater treatment is nearly always cheaper for residents in terms of cost per gallon. The economies of scale of public infrastructure allow multiple municipalities to share the costs of piping, pumping, and treatment.[6] There is also a consolidation of expertise in centralized plants; fewer engineers are needed to oversee one large plant.

Drawbacks

The main issues with centralized wastewater treatment are due to the centralization itself. Centralized plants disrupt local water cycles by drawing water from many locations and discharging it at a single site.[7] This increases the risk of flooding since the natural water cycles are disrupted, and wastewater and stormwater are sent to a single location, which often does not have the capacity to withstand the stormflow of an entire region. The urbanization of land also causes surface runoff to flow into stormwater drains, rather than through the local soil. Normally, rainwater drains through the soil, which keeps the nutrients contained in a local region. Due to urbanization, though, rainwater can flow through the topsoil into storm drains, removing critical nutrients (e.g., nitrogen and phosphorus) from local topsoil, which contributes to erosion and increased costs for farming and residential plant growth. Increased flooding also increases the risks of disease outbreaks since wastewater drains can overflow and send contaminated water to residential areas.[8]

Potential improvements

There are current steps being taken to address some of these issues – mainly by incentivizing local municipalities to introduce water recycling methods. Current wastewater collection systems combine all the wastewater into a single stream, even though not all wastewater is as difficult to manage as others. For example, greywater – a term used for wastewater without fecal contamination – can be used directly for domestic water purposes such as flushing toilets.[9] Greywater is also easy to treat and residential-scale treatment systems can convert it to potable water. Similarly, captured rainwater can be used for even more domestic tasks such as watering plants, showering, and cleaning.[10]

Unfortunately, there are no clear instances in which a centralized wastewater plant adopted greywater recycling,[11] likely because it is costly to build a duplicative piping system to service greywater. Rather, greywater recycling is left to individual buildings. Early adopters are primarily eco-conscious buildings because the capital cost and poor savings potential are insufficient for low-income residents. There are, however, proposals for decentralized greywater treatment plants on the community scale that may be more economically promising.[12]

Impact on Detroit Residents

The current political and economic climate in Southeast Michigan makes it difficult to implement some of the

improvement strategies for centralized wastewater treatment because the current pricing structure offers no incentives to recycle greywater or reduce the amount of wastewater produced by households. The Detroit Water and Sewerage Department (DWSD) uses meters to measure the amount of potable water a household consumes, and then charges a percentage of that for wastewater treatment. The assumption by water utilities is that most water that goes into a home comes out through wastewater, but this eliminates the incentive for households to reduce the amount of wastewater they produce. It also disproportionately affects older buildings where old pipes leak water, charging residents for potable water they do not use. And because of the rate structure, it also overcharges those same residents for wastewater treatment.

To implement a better cost structure (one that incentivizes wastewater recycling and accurately measures wastewater effuse), DWSD needs to add infrastructure such as additional metering, to independently charge residents for potable water and wastewater. It is unlikely that any water utility would undertake such a costly initiative without knowing that other costs would decrease, meaning that a wastewater recycling program needs to be established in conjunction with additional metering infrastructure. If municipalities reduce their wastewater through incentives, DWSD treats less wastewater, reducing their own operating costs and the savings can then be passed on to residents.

DECENTRALIZED WASTEWATER TREATMENT

Benefits

The most appealing aspect of decentralized wastewater treatment is its proximity to the sources of wastewater, which provides the following benefits: lower pumping costs, more sustainable water cycles, greater community engagement, and lower water consumption from residents. Decentralized plants often incentivize the use of recycling methods to reduce the amount of wastewater intake. Since water is reused, the energy input per gallon of consumed water can be lower.[7] Lastly, community members can participate more in the development of the treatment system including where it is located.

From an economics perspective, decentralized systems have a much lower capital cost because the overall size of the plant is smaller. Additionally, the piping distribution network which transports water to the treatment plants is much smaller. The cost of distribution piping is as high as 80% for centralized plants but is only ~25% for decentralized.[13]

Drawbacks

Although the capital costs are lower, the cost per gallon of consumed water is likely higher than centralized plants in urban areas where distribution piping is more efficient. Additionally, although the capital cost is lower, it falls exclusively on the communities it serves, rather than being spread out across multiple municipalities, making it a difficult alternative for poorer, urban communities. And even though there is greater community engagement, there is greater community responsibility, which poses a greater risk to failures and engineering challenges.

Many of the byproducts of wastewater treatment, such as nitrogen-rich organics, are potential goods to sell, but there is not a clear market yet. Much of the market is dominated by centralized plants, which have the infrastructure to ship large amounts of it directly to customers. Selling the same goods from decentralized plants would require smaller transportation vehicles, increasing the cost and reducing the income potential. Furthermore, there are additional waste byproducts with no value that need to be disposed of, which also require expensive smaller scale logistics.

Furthermore, decentralized wastewater treatment is in the nascent stage of technological development.[7,14] There is only a single instance of an urban municipality replacing or supplementing centralized wastewater treatment for a given area, in Boston, MA. Decentralized wastewater treatment has primarily been used to build out from existing infrastructure to meet the needs of new residential or commercial developments.[15] The primary economic barrier for existing municipalities to adopt decentralized plants is that they would be the first, and there are always engineering lessons learned in the initial stages of development. Early-stage technologies are at least twice as costly compared to their mass market state, and technologies often take decades to reach their mass market costs.[16] Any community to adopt supplemental decentralized wastewater treatment needs the resources to withstand the increased costs and risks.

Potential improvements

Many experts believe that DWTPs are the future of wastewater treatment because of all its benefits,[17] but the economic, political, and technological barriers prevent its adoption.[18] For municipalities to adopt decentralized wastewater as a supplemental wastewater treatment option, there needs to be further advancement in the technologies themselves, more cases of successful implementation, and changes to current water policy.

IMPLEMENTING DECENTRALIZED WASTEWATER TREATMENT IN DETROIT

The Great Lakes Water Authority (GLWA) owns the public infrastructure and only enters agreements that satisfy their procurement policy.[19] One of the key provisions of the policy is that any proposal must demonstrate that the economic benefits outweigh the costs.

The GLWA procurement policy also aims to mitigate risk which may harm their chances of approving a new technology, like decentralized wastewater treatment. As other municipalities with greater risk tolerance implement more decentralized plants, it can provide GLWA with confidence of the risk involved. Specifically, future advancements in microbial technologies are critical. Current microbial reactors, which are mainly used for decentralized plants, degrade too quickly. Additionally, decentralized plants currently require engineers and/or staff full-time to monitor treatment. Centralized treatment also has full-time staff, but they oversee much greater amounts of treatment, reducing the cost of personnel per gallon of treated water. In future years, however, improved automation and remote monitoring could reduce the burden on municipalities to operate their own plants.

If these issues are both addressed, then there is a clear path towards implementing a decentralized wastewater treatment plant in the Detroit city limits. Southeastern Michigan is in a unique position in wastewater governance because of the bankruptcy agreement between DWSD and the municipalities it served in 2014. Since the bankruptcy court binds many of the agreements between municipalities and GLWA, local municipalities have less control over their wastewater treatment compared to other regions in Michigan (or other states). There are instances of decentralized treatment, specifically for industry partners who treat their own waste. GLWA still monitors and regulates industrial discharge and must do the same for residential decentralized wastewater plants, so residential

decentralized plants would follow many of the same regulations and procedures, though there are also likely other regulations that control how a municipality builds and manages its own wastewater treatment plant.

Steps to build a decentralized wastewater plant:

1. Hire/consult an engineering firm to build and design the decentralized wastewater plant
2. Begin negotiations with GLWA about a neighborhood-scale decentralized wastewater plant
3. Establish decentralized wastewater facility as either municipal or commercial
    a. This circumvents some regulations of individual residential properties
4. Complete permits
    a. Construction permit
    b. MI criteria for subsurface disposal
    c. Part 22 groundwater discharge rules
    d. NPDES surface water discharge permits
5. Change rate structure to incentivize local water reuse
    a. Current rate structures are only a function of the clean water consumed.
    b. This can be done more easily and less costly on a community scale to leverage economies of scale. This is everything from repurposing stormwater to greywater recycling.
    c. The economics of the decentralized wastewater treatment plant likely fail if there is no incentive for wastewater recycling.

OTHER SOLUTIONS

Rate structuring

One promising way to lower the cost of wastewater treatment is to use equitable charging rates for different residents. This solution is potentially faster, cheaper, and more effective for reducing the cost of wastewater for low-income residents than any other solution. For the same reasons as discussed previously, lower income residents pay a larger fraction of their income on wastewater treatment. Recently, DWSD released a plan to lower the rates for low-income residents, but there are still major issues that water advocates have highlighted. An equitable rate structuring plan should have the following components (the actual components in the low-income rate restructuring from DWSD are compared):

1. Automatic enrollment – DWSD currently has manual enrollment. Cost-saving programs with manual enrollment experience far lower enrollment, and are consequently less effective.
    a. Once key issue with automatic enrollment is that the utilities need input from customers to determine what income bracket they fall under.
2. Income-based fixed and operating costs – the current DWSD affordability plan charges $18/mo to low-income residents for the first 4,500 gallons in a month, but this could be unavailable to low-income single-family homes with many residents that may consume more water, as there is no cost-savings for consumption over 4,500 gallons. Low-income households are more likely to house larger numbers of people to compensate for housing costs, and this policy likely harms or fails to help these households which are already high-risk.
    a. It is important to charge for additional water usage because lower water usage is healthy for the water cycle.
    b. The variable rate should still be income-based.
3. Geographical rate variance – not all water consumption is equal. Upstream, residential municipalities in the Detroit region contribute to flooding downstream in poorer neighborhoods. Additional cost measures should be adopted to help out these historically disadvantaged communities. There are no such provisions in the DWSD affordability plan.

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