Literature Review: Constructed Wetlands for Wastewater Treatment

Constructed wetlands are man-made wetlands that have been scientifically curated and engineered to mimic natural wetlands and their filtering processes. Through microbial activity, wetlands naturally treat wastewater contaminants and pollutants, providing a more biologically efficient method of wastewater treatment. Not only do wetlands provide ecological benefits, but they are also a more economically effective treatment compared to conventional municipal wastewater treatment plants. Constructed wetlands are traditionally used for domestic wastewater treatment, but in the last few decades, more and more have grown to become primary and secondary treatment systems for both cities and counties. Moreover, they can also be used as the final step in wastewater treatment, such as in Sewanee's constructed wetlands, removing any remaining nutrients. Constructed wetlands are a viable solution for many communities because they can reclaim water, recycling treated wastewater back into potable water through intensive treatment processes. Overall, constructed wetlands produce many benefits as they restore water, cut down on maintenance costs, and promote biological diversity.

Sewanee Constructed Wetland:

Our team is working with the Sewanee Wetland Research Station, a small experimental wetlands system in Sewanee that directs just over four liters of partially-treated wastewater per minute into the three wetland basins at Sewanee Utility District (SUD), adding a tertiary treatment step to the primary and secondary treatments. After wetland treatment, the water is then returned to lagoon C and released into the spray fields. Primary treatment consists of the physical removal of heavy solids. Here, sewage passes through a screen at Bob Stewman Road to filter solid waste out. From there, the wastewater passes through a splitter box which directs the wastewater into three treatment lagoons for secondary or biological treatment. Sewanee Utility District uses a total of 12.4 acres for these three lagoons. First, the wastewater enters lagoons A and C where it remains for 30 days. The bacteria, algae, and microorganisms in the lagoons treat the wastewater. It then flows down to lagoon C, where it spends 15 days before either being treated with chlorine and sprayed onto 60 acres of forested land or redirected into the constructed wetland basins. The wetland's design is such that water moves through the system by gravity flow from north to south. Passing through three basins, the water discharges back into lagoon C, where it is sprayed onto the fields as cleaner wastewater.

Water from lagoon C flows into a storage tank where sensors and switches control how much water enters the first wetland basin. The water exiting lagoon C and entering wetland basin 1 first flows through a rock cascade: “This process adds oxygen to the water, which facilitates oxygen-requiring treatment processes.” Additionally, wetland vegetation absorbs excess nutrients from the wastewater through their roots. When the vegetation dies, it causes the oxygen levels in the water to decrease because of the surge of nitrogen due to dead plant material. The final wetland basin has an artificial aerator to add oxygen to the system to ensure the plants can continue to treat wastewater effectively. Milkweed, softstem bulrush, and pickerelweed are all planted in the wetland basins. All vegetation in the wetlands is herbaceous, meaning they have flexible green stems and no woody parts. Furthermore, the plant's “species composition [is] selected for tolerance to varying depths of water.” The vegetation provides a structural substance layer for flowing water filtration and biofilm (microorganisms that stick together near the surface) development so that it resembles a native wetland in the Cumberland Plateau region.

Clayton County Constructed Wetland:

The design of Sewanee’s constructed wetlands is a much smaller-scale system compared to the other systems around the country which treat entire counties’ and cities’ wastewater; however, the treatment process and economic and biological effects are relatively the same. In Clayton County, Georgia, the Clayton County Water Authority (CCWA) created a larger-scale system of constructed wetlands, switching over from their previous irrigation systems. The CCWA found that the constructed wetlands “require much less land, energy, and maintenance than the irrigation systems” (Clayton County Water Authority). Additionally, CCWA estimates the cost to build wastewater facilities using constructed wetlands at $4.73 a gallon compared to nearly $10 a gallon using the more conventional methods.

The CCWA’s constructed wetlands reduced both the amount of staff required to operate the system daily and the equipment needed to treat wastewater. Instead of routine maintenance of pipes, valves, chemicals, and machinery; wetland management primarily consists of vegetation management, removing the plants that grow in the system, so the wetland can continue to treat wastewater effectively. This only requires a few workers, rather than, a full-time staff every day. The previous wastewater treatment operation needed 100-150 acres of land for irrigation but now only needs 20-25 acres for wetlands treatment.

As an additional bonus, the constructed wetlands system provides an ecosystem for nesting and migratory aquatic birds: “Coastal and wading birds such as the Great Egret, Ibis, and Rails can be seen on occasion wading the shallow marsh zones. Plus, waterfowl such as Canada Geese, Mallards, and Gadwall frequently stop over during their migration in the winter” (Clayton County Water Authority).

The constructed wetlands in Clayton County recycle treated wastewater back into the drinking water system, allowing for the reclamation of twenty million gallons of used water per day, which is stored in reservoirs and reused for drinking water. This method of wastewater treatment and water recycling is useful for areas that experience long periods of drought or low rainfall, like the system in Orange County, California, or the systems in Arizona. The most difficult hurdle is convincing the public that recycled water is perfectly safe as long as it’s treated properly.

Constructed Wetlands in Arizona:

In Arizona, constructed wetlands are used in 26 different cities, with over 20 under construction or under approval to treat wastewater. The costs associated with the wetlands in Arizona are parallel to the other systems across the country, like the system in Tres Rios, Arizona. Tres Rios’ system only needed eighty million dollars to upgrade to a full-scale wetland wastewater treatment system; whereas, an upgrade to a conventional treatment system required up to 625 million dollars. Comparatively, one traditional treatment facility in Jerome, Arizona had a cost of 1,000 dollars per month for the town of 416 people, compared to a cost of almost zero for the constructed wetlands in their town.

It is clear, in these examples, that the costs of constructed wetlands are unparalleled, but their drawbacks are known less. Because wetlands are a recent development in wastewater treatment, there is not enough data on their treatment of harmful chemicals like ammonia or difficult removables like pharmaceuticals. Although constructed wetlands are more cost-effective than conventional methods, this is mostly only true for areas where land is more available for use and where land is less expensive. In big cities, like New York City, this wastewater treatment is impossible and is not cost-effective. Constructed wetlands thrive in areas that have large amounts of land available and also areas that have consistent seasons because wetlands are less adaptable to change compared to municipal treatment facilities.

In Sewanee, there is enough land available, but there are remaining questions: Can the constructed wetlands remove the extra harmful pollutants from the wastewater that our previous method could not? Can the constructed wetlands eventually take on the entire community's wastewater while continuing to meet EPA's water quality standards? Constructed wetlands wastewater treatment systems are extremely effective at a larger scale, such as the ones in Clayton County. However, our team wants to know if these systems work as well in a rural smaller-scale setting.

References

- *Case study: The Clayton County constructed wetlands —*. (n.d.). Sewanee Wetlands. Retrieved June 22, 2022, from http://sewaneewetlands.org/case-study-the-clayton-county-constructed-wetlands
- *Constructed wetlands —*. (n.d.). Sewanee Wetlands. Retrieved June 22, 2022, from http://sewaneewetlands.org/constructed-wetlands
- *Constructed wetlands: Using human ingenuity, natural processes to treat water, build habitat*. (2011, December 9). Wrrc.Arizona.Edu. https://wrrc.arizona.edu/publications/arroyo-newsletter/constructed-wetlands-using-human-ingenuity-natural-processes-treat-wa
- *Facts about OCWD's Prado constructed wetlands*. (n.d.). Ocwd.Com. Retrieved June 22, 2022, from https://www.ocwd.com/news-events/newsletter/2019/january-2019/facts-about-ocwd-s-prado-constructed-wetlands/
- Oscar Omondi, D., & Caren Navalia, A. (2021). Constructed wetlands in wastewater treatment and challenges of emerging resistant genes filtration and reloading. In A. Devlin, J. Pan, & M. M. Shah (Eds.), *Inland Waters - Dynamics and Ecology*. IntechOpen.
- Thomas, M. (n.d.). *Sustainable water resources management by Georgia utilities: Clayton county water authority*. Gatech.Edu. Retrieved June 22, 2022, from

https://smartech.gatech.edu/bitstream/handle/1853/47145/ThomasMike%20paper%20April%2013.pdf?sequence=1&isAllowed=y

- *Water recycling in Clayton county, Georgia*. (n.d.). Climate.Gov. Retrieved June 22, 2022, from https://toolkit.climate.gov/case-studies/water-recycling-clayton-county-georgia
- *Wetland design —*. (n.d.). Sewanee Wetlands. Retrieved June 22, 2022, from http://sewaneewetlands.org/wetland-design