FROM WASTE TO FUEL: ANAEROBIC DIGESTION IN WATER TREATMENT

Tristan Witek, tw65@pitt.edu, Vidic, 2:00, Emma Minck, ecm63@pitt.edu, Sanchez, 5:00

Current Water Treatment Methods

Wastewater treatment centers follow general steps:
- Primary treatment - initial filter to remove larger suspended solids
- Secondary treatment - removes dissolved organic matter through the use of microorganisms and settling tanks
- Tertiary treatment - Excess impurities are disinfected chemically with chlorine

The water is returned as surface and ground water, but any water to be used for drinking continues through a second process:
- Coagulation/flocculation - bind particles together to enlarge them
- Sedimentation - allows the large particles to settle at the bottom of the tanks
- Filtration - manner similar to the primary treatment of wastewater, removing large particles
- Disinfection - done so chemically, also through the use of chlorine

Case Studies

Pittsburgh, Pennsylvania
- Bolt water advisory issued early February, 2017
- Issue caused by low chlorine levels in drinking water
- Lasted two-three days
- Symptoms of ingesting water without boiling: nausea, headaches, fever, diarrhea, and vomiting

Chapel Hill, North Carolina
- Bolt water advisory issued February, 2017 by Orange County Water and sewer Authority
- Issue caused by broken water main that allowed bacteria to grow in the still water
- Lasted several weeks
- Demonstrates a need for structural improvements of water treatment and transportation

Flint, Michigan
- First bolt water advisory in April, 2014
- Issue caused by fecal coliform bacteria detected in the water
- City flushed the system and increased amount of chlorine in the water
- The chlorine killed off and resulted in more bolt water advisories as new reports of illnesses were reported across the city
- Issue still continues, more than 17,000 residents have filed a $722 million class action lawsuit against the EPA

“Cancer risk among people using chlorinated water is as much as 93% higher than among those whose water does not contain chlorine.”
- The U.S. Council of Environmental Quality

Effects of Chlorination

Too little chlorine...
- Water is not entirely disinfected
- Disease carrying bacterium such as E-Coli and coliform can still be present in the water
- Too much chlorine...
- Residue lasts and builds up over time, decontaminating the water
- Symptoms increase, especially in children and the elderly, causing nausea, headaches, fever, diarrhea, vomiting, etc.

What is Anaerobic Digestion?

Anaerobic digestion uses a genus of bacteria called anaerobic bacteria and only happens in environments devoid of gaseous oxygen. Once in this environment, they follow a series of processes:
1. Hydrolysis: the process of breaking down the non-soluble proteins, carbohydrates, and lipids that make up the fecal matter into amino acids, sugars, and fatty acids
2. Acidogenesis: Re-digests previous compounds into ammonia, volatile fatty acids, and alcohols
3. Acetogenesis: draws from the compounds of first two steps to form acetic acid, hydrogen, and carbon dioxide
4. Methanogenesis: bacteria process the acetic acid, hydrogen, and carbon dioxide to produce methane gas, and more carbon dioxide.

The methane and carbon dioxide, both being gases, bubble out of the solution, forming an atmosphere of organic gases overhead. Thus, on an elemental level, everything that once was a part of the fecal matter either became gas and removed itself from the former wastewater, or stayed behind to keep the bacteria alive, allowing the same bacteria to continue digesting other organic matter in the wastewater.

Implementation

The city government of Whitewater, Michigan projected that the cost for a new plant, with the cost of technology included, would be $976,000. Current, typical wastewater treatment systems cost around $500,000-$1,000,000.

- However, when considering how many plants there are to upgrade, the cost ends up being around 17 billion dollars, even with the 4,000 direct upgrades
- Spreading out the cost of upgrading such that only a few hundred plants receive upgrades each year makes the original price tag more manageable
- Current plants cost around $333,000 to maintain per year; Anaerobic digesters cost $11,000-$51,000 per year
- When anaerobic digesters are built from the ground up, they not only take less space than current treatment systems, but also take significantly less space than the result of trying to directly upgrade current plants

Sustainability and Societal Impacts

Environmental Impacts
- Collects methane, a notable greenhouse gas, and can be used for energy instead
- Can reduce the dependence on power plant driven technology
- Collection is easy and renewable, lowering need for oil or coal or fracking

Social Impacts
- Water is cleaner and more available
- Reduced air pollution resulting in better public health
- More space for those living near treatment facilities and less odor

The entire process filters and cleans water in a manner current wastewater treatments cannot accomplish without some level of contamination. Present chemical treatment is rather dangerous and tends to cause more long term problems that outweigh the immediate satisfaction of supposedly clean water. Anaerobic digestion is a process that cuts down on the toxicity of wastewater and provides the very thing that civilizations live and thrive on.

Advantages
- "Left over" materials, such as Carbon Dioxide and Methane, are removed in the form of gases or reused in the process as it repeats
- Does not need to be as monitored as chlorination does
- Naturally occurring process
- Methane produced can be used as a source of renewable energy

Disadvantages
- Digesters are relatively new and not widely used technology
- Many wastewater treatment centers could not simply incorporate it and would have to be completely reconstructed
- Temperature and pH level do require some monitoring
- Chance of some odor due to high number of methanogens