=

City of Beloit Water Pollution Control Facility

Sam Kupersmith
Environment and Society
March 21, 2008
Beloit as an Ecosystem

"A 'sewerage system' is the collection of all structures, conduits and pipes, by which sewage is collected, treated, and disposed of, with the exception of building plumbing and the service pipes from the buildings to municipally owned sewers" (Wastewater 2006). This is not to be confused with a stormwater system which simply redirects water runoff to another body of water without processing it (Caskey 2004).

On March 17, 2008 several Beloit college students paid a visit to the City of Beloit Water Pollution Control Facility. We were given a guided tour by Gary Zimmerman, one of the three operators of the plant. Except where otherwise noted, the information in this document comes from Mr. Zimmerman.

The City Of Beloit Water Pollution Control Facility lies on a 60 acre municipal parcel of land located at 55 Willowbrook Rd just west of interstate 90 in the Southeastern portion of the city (Beloit 1992). The facility is shared with the water utility (Beloit 1992). Construction was completed and the facility was dedicated to the city of Beloit on May 30, 1992 by the city council (Beloit 1992). Initial funding came from the state of Wisconsin which provided a $30 million grant and approximately $26.4 million from city sources (Beloit 1992). There are currently 28 full time employees, including a repair crew, environmental technicians and plant operators as well as administrators and their staff (Beloit 2008). The facility's monetary expenditures since 2004 have been between $7.2 million and $7.9 million dollars annually (Beloit 2008).

The facility is staffed from 6 am to 6 pm on a daily basis. Automated dialers call technicians if there is a system malfunction or disturbance. Preventative maintenance such as exercising valves to insure that they do not lock up is performed on a regular basis. According to Mr. Zimmerman, the whole process comes down to "basically a big babysitting job."

The importance of this facility and facilities like it, to the city of Beloit, the Rock River watershed and all life on earth is definite. If not treated, sewage would cause lakes and rivers to become extremely polluted. Currently, an average of about 6 million gallons of water are processed a day at the Beloit facility.

- **Sources of water**
    - Household sources
        - Toilet
        - Shower
        - Dishwasher
        - Washing machine
        - Garbage disposal

        - Sinks
    - Industrial sources
        - Frito lay
        - Fairbanks

In addition to direct sources, water is able to seep into the underground sewer piping and through small cracks throughout the system. This is generally evident in times of precipitation or melting. The facility peaked at 22 million gallons on a single day in 1993 due to an extremely wet spring. Although water will inevitably be able to get into the system, it does not leave the system due to the outside pressure on the piping.

Path of Water from Source to facility:

When water goes down the drain and into the sewer system it flows by the power of gravity to 1 of 12 pumping stations located throughout the city. These stations are remotely monitored from the treatment plant at 55 Willowbrook Rd. Each station has a number of pumps and a large pool. Electronic sensors determine the level of the water in the pool and turn the pumps on and off according to the desired level of each pool. As part of routine maintenance, the pumping stations are periodically drained. This causes built up sewage to be washed into the system effectively cleaning the pipes.

Water Pollution Control Facility

Forced Main

Wastewater is pumped from the pumping stations into the pollution control facility through a single pipe called the **forced main**. Like most important structures in the facility, there are 2 forced mains. This redundancy is extremely important in case the operating structure fails there is a backup ready to be used immediately.

Forced Mains (about 3 feet in diameter)

Bar Screens

After passing through the forced main the water flows through an appropriately named structure called the **Bar Screens**. The bar screen is a conveyor belt-like structure that is composed of interlocking metal bars filters out any large solids that may have entered the system. As wastewater passes through, the belt lifts these solids out of the water and moves them to a conveyor belt that transports them to a temporary storage area.

Bar Screen (about 2 stories tall and 2 to 3 feet wide)

The list of items that are collected by the bar screen is quite extensive. In a single afternoon Gary created a list of items that includes the following:

Apples, Bic-lighters, Bic-razors, bananas peels, balloons, bras, band-aids, beans(all types), brushes, buttons, barrettes, bar soap, birds, batteries, bottle caps, cigarette butts, corn, combs, cassette tapes, condoms, condom wrapper, celery, chicken bones, crayons, carrots, cigars, candy wrappers, dishtowels, diapers, fish and other pets, frogs, grapes, gerbils, gum, grapefruit, grease balls, goldfish, hotdogs, hamsters, hair ribbons, hypodermic needles, hair curlers, jewelry, Kotex, leaves, lettuce, lip-stick, mice, underwear, money, mustard packs, nylons, orange peels, onions, oranges, plastic (all types), potatoes, popsicle sticks, pens, pencils, plastic toys, peas, panties, panty liners, paper, pine cones, rubber bands, rats, syringes, sucker sticks, snakes, sticks, string, small stones, stirrer sticks, super balls, twist ties, teeth, tape, Tampex, tin foil, tomatoes, tree roots, toothbrushes, toads, tadpoles, washrags, watermelon, wood, worms, and a lot of unknown items.

Pista Grit Removal System

After passing through the bar screen, water enters the second treatment site called the **Pista Grit Removal System.** The Pista Grit's function is to remove inorganic solids that are too small to be collected by the bar screen. It accomplishes this by creating a vortex in a cylindrical pool that has a small hole in the bottom. Solids, such as sand and small pebbles, fall to the bottom of the pool where they pass through the small hole and are then moved by a conveyor belt to the same temporary storage area that the larger objects from the bar screen are sent. After about a week the waste from these two filtering processes is sent by dump truck to the dump.

Generic Pista Grit removal system
(http://www.idswater.co.in/Common/Exhib_2319/grit_removal2.jpg)

Looking into Beloit Pista Grit

← Temporary storage area above truck loading area drops large solids into bed of dump truck when electronic motor is activated.

After passing through the bar screen and the pista grit, inorganic solids have been considerably reduced. Anything that remains is very fine in texture and will be removed later.

Primary Clarifier

After having inorganic solids removed, the water flows through the Primary Clarifier which is a 750,000 gallon, open-air tank equipped with two rotating arms. The upper arm collects material that floats on the surface and is connected through a series of metal structures to the lower arm that collects anything that sinks. The material that floats is referred to as primary skimmings and is composed mostly of grease. Together they are called primary effluent. The facility has two primary clarifiers but is currently only operating one of them.

Primary Clarifier


Other primary clarifier – half full and not currently in use (note the metal structure between the upper and lower arm)

When in use, the primary clarifier maintains a constant water level of 17 feet. It does this by allowing all water to fall over sides as water level rises as shown in picture below


Water flowing out of in- use primary clarifier

Primary effluent is pumped through a system that removes most of the water. The left over material is now called biosolid. The biosolids are sent to one of the two **Anaerobic Digesters** where they sit for about 30 days in an oxygen free environment.

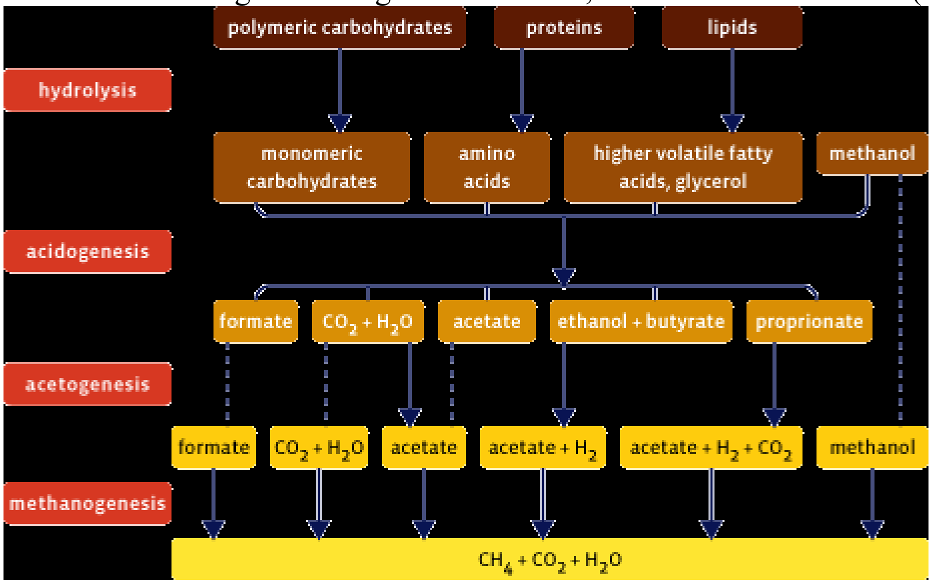
Anaerobic Digestion

Anaerobic digestion (fermentation) occurs when various types of naturally occurring bacteria degrade the effluent collected from the bottom and top of the Primary Clarifier in an oxygen free environment to produce methane and carbon dioxide biogases (Renewable 1997). In order for the process to be effective, the digestion tanks must be maintained at a stable temperature and acidity. If the environment is not favorable to the correct types of bacteria then the process will be very inefficient (Biogas 2003). The Beloit digesters are maintained at about 100˚F in what is called a thermophilic environment. For best results, pH of the system is maintained between 6.8 and 8.0. In order to maintain uniform consistency, the effluent is continuously stirred. Since this is an anaerobic environment, the tanks must be sealed from atmospheric oxygen. The production of biogas within the tanks creates pressure. Too much pressure could result in an explosion so the pressure within the tank is maintained at about 7.8 inches of H20 pressure.

Processes involved in Anaerobic digestion

- **Hydrolysis** and **Acidogenesis**
  - Microorganisms secrete enzymes such as lipases, proteases, cellulases, and amylases.
  - Theses enzymes break down or hydrolyze larger molecules such as lipids, proteins, and carbohydrates into smaller molecules such as amino acids and sugars.
  - The amino acids and sugars are then further broken down to volatile fatty acids (VFA), aldehydes, alcohols, carbon dioxide, and hydrogen.
- **Acetogenesis**. Microorganisms called acetogens degrade VFA's, aldehydes, alcohols to acetate, H2 and CO2.

- **Methanogenic** bacteria carry out the final step in anaerobic respiration by forming methane gas from acetate, and from H2 and CO2. (Biotim)



http://www.water-leau.com/media/images/ST10.gif

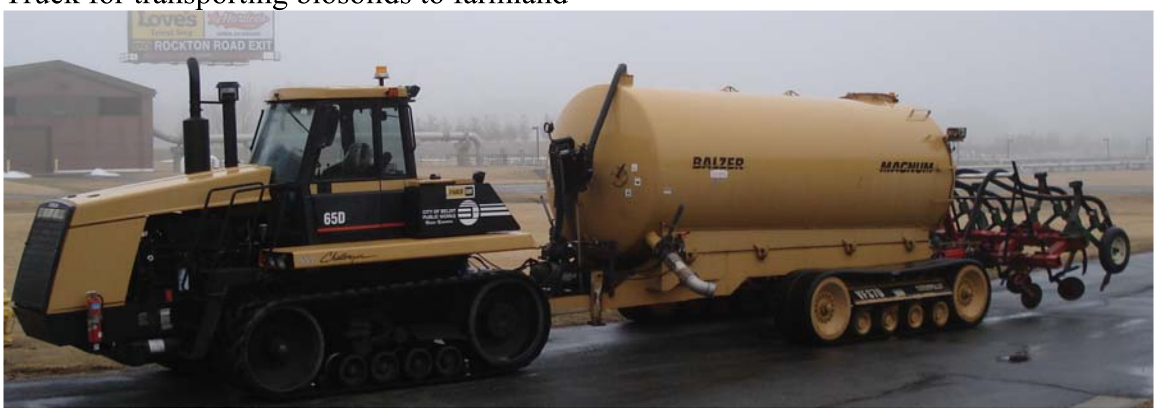
At some facilities the methane gas released from anaerobic digestion is used to power a generator. At the Beloit facility there is not enough methane to justify the expense that would be required to upgrade the facility. Although some of the gas is used to heat the digesters to the correct temperature. Sadly, any access methane is burned off rather than being used for another process such as generating electricity.

Methane Flare (not currently operating)

After the biosolid has spent about 30 days in the digester it is pumped to one of the two **storage tanks**.

Storage Tanks

Biosolids remain in one of the two 4 million gallon storage tanks for a minimum of 180 days as required by law. Unlike the anaerobic digesters, the storage tanks are not sealed off from the atmosphere. Before the growing season begins they are trucked off to farmland to be used as an effective fertilizer. It is important that the solids are injected several inches into the soil rather than just sprayed onto the soil's surface, to prevent rainwater from washing it away. Before use, it is important that the biosolids are tested for heavy metal concentrations. The facility tests for cadmium, chromium, copper, lead, nickel, and zinc.


Truck for transporting biosolids to farmland


Machinery used to inject biosolids into soil

Aeration Basin

After the water passes through the primary clarifier it is sent to the heart of the operation, the **Aeration basin** also called the a-basin**.** There are four, 1.75 million gallon a-basins at Beloit but only two are in current use. Each basin is divided into two zones. The first zone is called the anoxic zone. The anoxic zone is easily identified by the lack of bubbles on the surface of the water The purpose of the anoxic zone is to kill off undesirable bacteria called filamentous bacteria.

After passing through the anoxic zone, water flows into an oxygen-rich environment where the dissolved oxygen level is maintained at or above 1.5 ppm. Large blowers force air through pipes at the bottom of the a-basin causing the water to become highly oxygenated. Naturally occurring bacteria thrive in this environment and as a result degrade most of the remaining biological waste. The type of bacteria in the aeration basin determines the efficiency of the system as a whole. Daily water samples are analyzed for the bacterial content. The presence of rotifa bacteria indicates a well operating system.

Aeration basin – The anoxic zone is the area on the left side of the screen without any bubbles. The picture on the right is of the oxygenated region.

Secondary Clarifier

After passing through the a-basin, water then goes into the **Secondary Clarifier**. The secondary clarifier is the same as the primary clarifier except much less effluent is collected. Anything that is collected is piped back through the a-basin.

Secondary Clarifier – the water in this is clear enough to see several feet down

Disinfection Tanks

The water then moves to the **disinfection tanks** where it is treated with sodium hypochlorite to kill the bacteria and then treated with bisulfite to precipitate the hypochlorite.

Disinfection tanks

Disinfection building

Chemical tanks

Water leaving treatment plant

Special thanks to Plant operator Gary Zimmerman for giving us a tour of the facility and to Environmental technician Richard Douglas for answer questions about the facility.

Unless otherwise stated, all pictures were taken by Sam Kupersmith on March 17, 2008

Works Cited

Beloit Public Works. 1992. City of Beloit water pollution control facility. Beloit, Wisconsin.

Beloit. Public Works. 2007. City of Beloit, Wisconsin enterprise funds: Water pollution control. http://www.ci.beloit.wi.us/vertical/Sites/%7B4AECD64A-01FA-4C24-8F53-D3281732C6AB%7D/uploads/%7B20241E0D-0114-428A-80CC-652E7EFE2A92%7D.PDF. Accessed 21 Mar. 2008.

Caskey, D. 2004. EH & S Fact sheet - Sanitary and storm sewers. http://ehs.uky.edu/ep/sewer.html. Accessed 26 Apr. 2008.

FAO World Agriculture Information Center. 1997. Renewable biological systems for alternative sustainable energy production. http://www.fao.org/docrep/w7241e/w7241e0f.htm#4.1.1%20hydrolysis%20and%20acidogenesis. Accessed 19 Mar. 2008.

Habmingern. 2003. Biogas Production. http://www.habmigern2003.info/biogas/methane-digester.html. Accessed 21 Mar. 2008.

Waterleau: Protecting the Blue Planet. 2008. BIOTIM anaerobic wastewater treatment. http://www.water-leau.com/default2.aspx?PageId=123. Accessed 21 Mar. 2008

Wisconsin Department of Natural Resources. 2006. Wastewater systems plan review. http://dnr.wi.gov/org/water/wm/glwsp/facilities/. Accessed 21 Mar. 2008.