Understanding High BOD in Wastewater

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What is wastewater?

- **Wastewater**, also written as **waste water**, is any water that has been adversely affected in quality by anthropogenic influence. Wastewater can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and from sewer inflow or infiltration.

What is “Treatment”?

- What contaminants are in the water?
- What contaminants need to be treated, changed or removed?
- What processes or combination of processes can do the work?
- How clean does the water need to be?
    - Appropriate use/reuse.
    - Complex treatment system?
        - Reuse/irrigation
    - No treatment at all?
        - Land App
        - “Straight Pipe”

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Why treat wastewater?

Effects on the receiving environment

- Oxygen demand
  - Hypoxia
- Nutrient load
  - Eutrophication
- Toxic effects
  - Industrial effluents
  - Mining
- Odor

Surcharges

Reuse

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What is BOD?

- Biochemical Oxygen Demand
  - The oxygen demand that the wastewater would exert on a receiving water body
  - There are other “oxygen demands” and sub-types
    - Chemical
    - Nitrogenous vs carbonaceous
  - Particulate vs. Soluble
  - Generally measured as a mass load or concentration

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Critical Design and Process Constituents

- Flow
- Carbonaceous substrates (BOD, cBOD)
- Chemical Oxygen Demand (COD)
- Nitrogenous compounds (TKN, OrgN, NH_4-N, NO_3-N)
- Phosphorus compounds (TP)
- Total suspended solids (TSS)
- Volatile suspended solids (VSS)
- Alkalinity ($CaCO_3$)
- Turbidity
- pH
- Coliform (total coliform, fecal coliform, *E. coli*)

What is Mass Load?

- Concentration or “Waste Strength”
- Hydraulic flow

Without both, you are clapping with one hand.

- 8.34 x (BOD) x mGal/Day = Load (lbs)

However, for smaller flows:

- 8.34 x (BOD) x (Gal/day) / 1,000,000 = Load (lbs)

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What is waste strength?

- Raw sewage is actually far cleaner than Ivory soap…
  - Units used for measuring constituents in wastewater are mg/L or ppm
  - That is a small quantity
  - 99.44% water is quite close to accepted values for Brewery Wastewater!

What is Municipal Waste Strength?

- BOD – 250-450 mg/L
- TSS – 200-400 mg/L
- FOG – 20-150 mg/L

- This is typical “Sewage” from residential sources.

What is High Strength Waste?

- Higher than “Municipal”
- Much greater variation in character and flows
- BOD - >450 mg/L
- TSS - >200 mg/L
- FOG - >150 mg/L

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High Strength Wastewater and Pretreatment Programs

- How high can BOD go?
  - 1000, 5000, 10,000 mg/L ?
- Regulate based on total load?
  - Probably most “fair”, but takes more effort
- Regulate based on concentration?
  - Possible side effect, water efficiency not incentivized
- Categories for concentration?
  - Encourages either staying in a category, or “dumping everything” once the highest category is reached.

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So What?

- “It is just a little sugar water”
- “It’s completely organic”
- “It isn’t sewage”
- “It just ends up as food for other animals”

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Examples

- Breweries
- Beverage Bottling
- Fruit and Vegetable Processing
- Meat Processing
- Milk/Dairy Processing

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Brewery Wastewater

It’s just a little rinse water…

- Dissolved sugars
- Alcohol
- Particulates
- Yeast
- Chemicals

Brewery Wastewater

- BOD – 600-5000 mg/L
  - Side streams can be much higher!
- TSS – 200-1500 mg/L
  - Side streams can be much, much higher!
- pH – Lower than Neutral (typically)
- Intermittent “shock” loadings with various processes and cleaning operations.
- BOD load can exceed 20 times more load than municipal sewage on average, with spikes much, much higher!
- Breweries are typically brewing and packaging operations combined

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Beverage Bottling

Beverage Bottling

- BOD – 3000-7000 mg/L
  - Unique events can be enormous (can/bottle crush)
- TSS – varies mg/L
  - Can vary enormously depending on application
- pH – Lower than Neutral (typically) Most juices, soda, kombucha, wine, beer and other drinks are acid.
- Intermittent “shock” loadings with various processes and cleaning operations. Poor manufacturing runs are often disposed of in the system after a “crush” to reduce volume of refuse.
- BOD load can exceed 20 times more load than municipal sewage on average, with spikes much, much higher!

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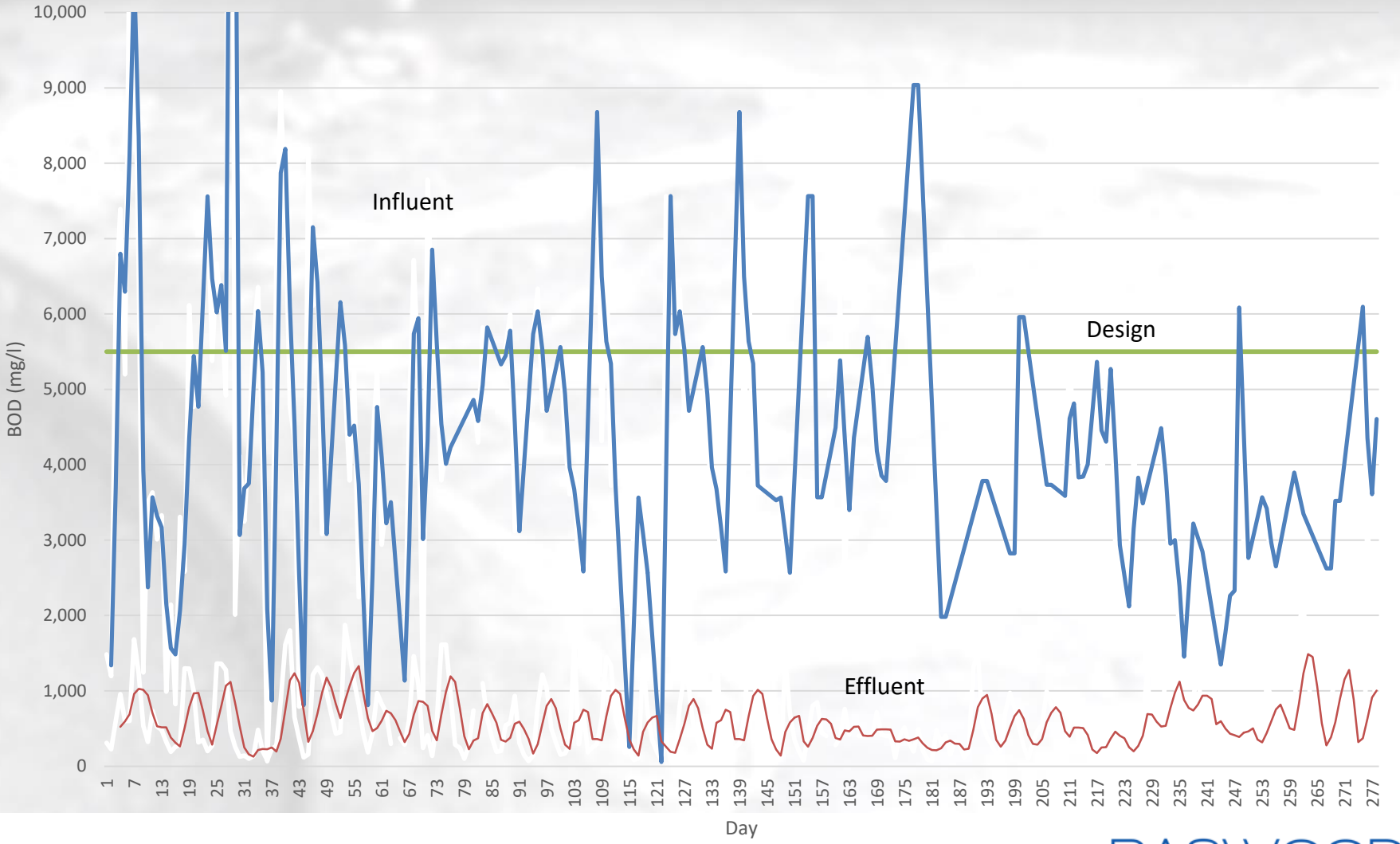
BOD Data (April 2016 – Dec 2016)



Fruit/Vegetable Processing

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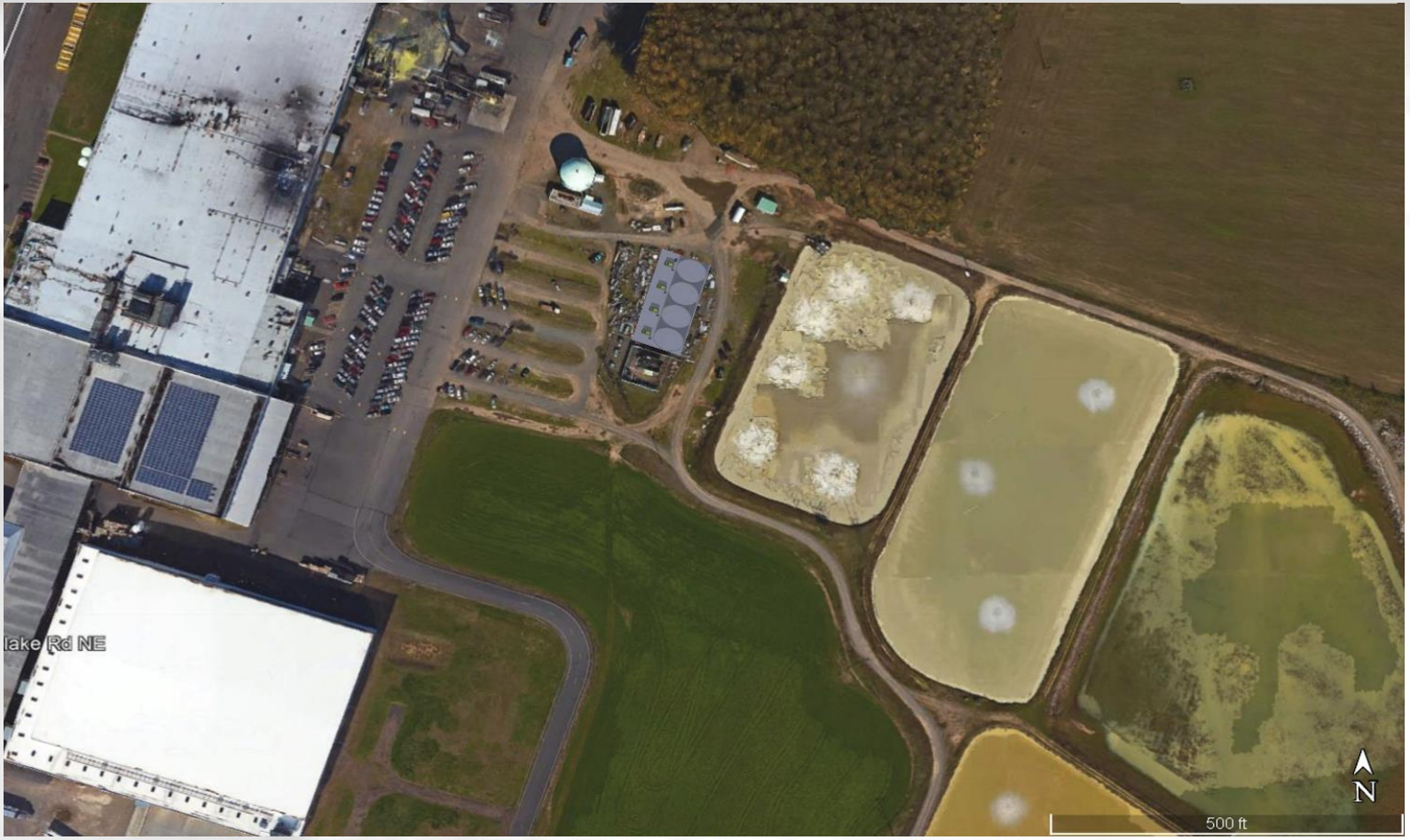
Fruit/Vegetable Processing



Meat processing

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Milk/Dairy Processing

Here is something to think about…

- One can of this soda has 46 grams of sugar
- One can of soda is 12 ounces
- Let's imagine that a resident in a home that generates 200 gpd spills one can of soda per day
- Sugar is $C_6H_{12}O_6$

One 12 ounce can of soda per day can increase the BOD load of an average household by 10%

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Fundamental Processes of Waste Water Treatment

Physical/Mechanical

Biochemical

Chemical

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Wastewater Treatment – Biochemical

Aerobic

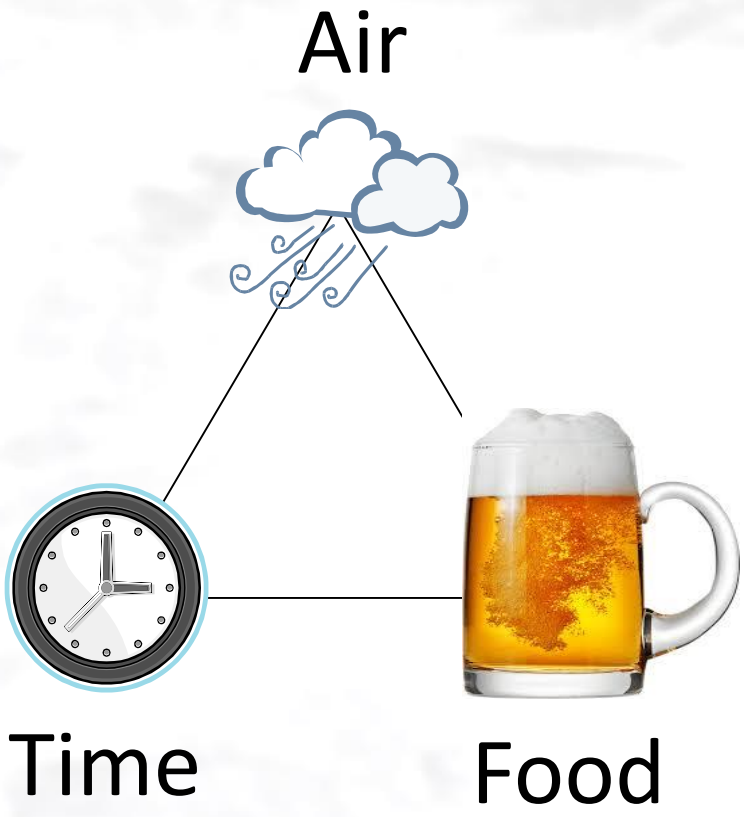
- Carbon compounds + microbes + Oxygen =
- Carbon Dioxide +Water + More microbes
  - With available dissolved oxygen
  - Rapid, efficient, more complete

Anaerobic/Anoxic

- Without available dissolved oxygen
  - Oxidant may be Nitrate, Sulfate, etc (Anoxic)
- Slow, inefficient, incomplete at room temp
- Can produce Methane or “Biogas”
- Greater Odor Potential

Wastewater Treatment - Biochemical

Balance these 3 in the correct proportions and in the correct forms



Wastewater Treatment - Biochemical

- Without aerobic processes, the organic carbon isn't completely broken down to carbon dioxide and water
- The volume of air required and the rate that the air is supplied depend upon the wastewater characteristics
- Whether it's a large municipal activated sludge system, a brewery or an individual home system, the processes require virtually the same things.

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Wastewater Treatment - Biochemical

- Maximum dissolved oxygen concentration in water at 70^0 F is 9.0 mg/L
- Oxygen concentration in atmospheric air is around 275 mg/L
- It takes almost 59 cubic feet of air for 1 pound of oxygen

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Critical Design and Process Constituents

Flow – How much water must be treated every day?

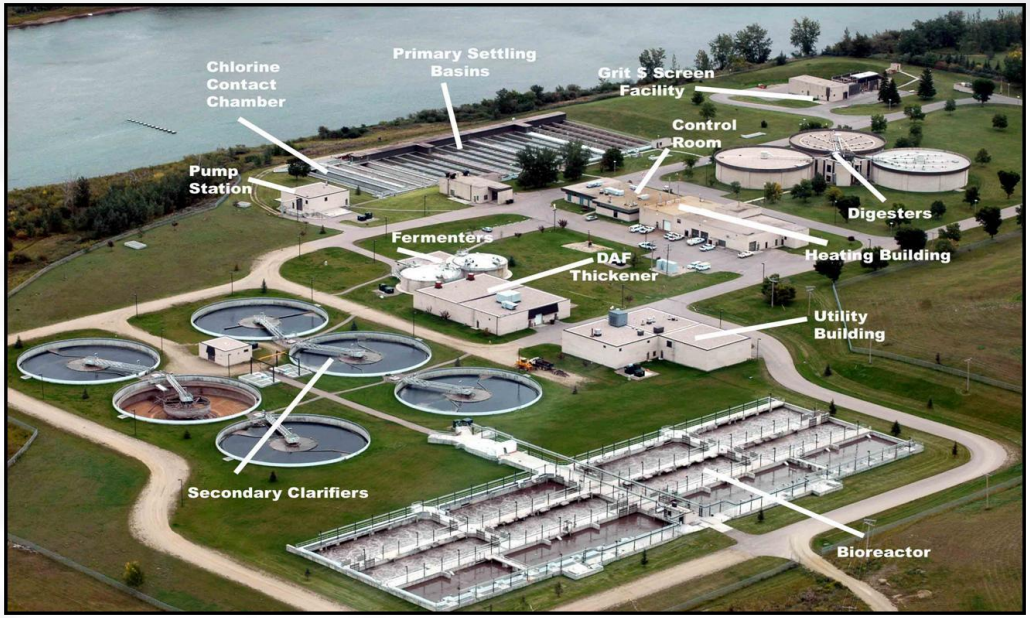
Food – How much food is in the wastewater?

Air – What is the Oxygen requirement?

Time – How much room is there on the property? How large do the tanks need to be?

Unit Processes of Wastewater Treatment

- Grit removal
- Primary sedimentation
- Aeration
- Final sedimentation
- Disinfection
- Return to receiving environment



Questions?

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