A Recipe for High Strength Waste

Presented by: Allison Blodig, REHS
Owner, GYST Consulting
Yet another challenge of owning a restaurant...

- For many current and potential restaurant owners onsite treatment is the only choice.

- Depending on the size of the facility, the menu, and the practices in the kitchen, wastewater strength can range between 2 and 10 times higher than residential strength wastewater.

- Why?
  - A lot of organic material goes down the drain.
  - Rarely are there washing machines or showers to help dilute the wastewater.

- Many designers and regulators lack experience in high strength wastewater system design.

- With every other challenge that comes with running a restaurant this is one thing can be avoided.
Critical Program Requirements

- According to the EPA in 2005
  - States must consider special characteristics and requirements of commercial, industrial and large residential systems
  - States need to implement technical guidelines for site evaluation, design, construction and operation/maintenance.
- O & M and routine sampling are key elements
- While costly, knowing that these may be requirements for high strength systems may make some restauranteurs think twice about opening a restaurant.
- This presentation will focus primarily on technical guidelines for designing and reviewing commercially available wastewater treatment systems.
What happens if you don’t understand?

- Propensity to use soil or residential aerobic system designs and simply add a grease trap or interceptor.
- Rely on untrained engineers or designers to understand.
- Systems that are put in are not reliable or sustainable and lead to catastrophic failures and/or repair costs.
- This can lead to financial hardship and even ruin for the people who counted on someone to understand.
The Basics

- **Biochemical Oxygen Demand or BOD$_5$ (BOD)**
  - The amount of organic material requires aerobic microorganisms to break down the waste
  - This will be our focus in this presentation
  - We will assume that all other parameters have been accounted for in the design
    - Like grease trap/interceptor requirements; additional screening or settling for high solids; nitrogen removal requirements.

- **Three main design components**
  - Determining the expected BOD loading in pounds per day
  - Determining the aeration capacity for BOD removal of a pre-engineered system
  - Sludge production and management
BOD Strength

- A study performed by Lesikar in 2004 in Texas showed:
  - 75% of wastewater samples from 28 different kinds of restaurants were 1400 mg/L or less with an average of 1000 mg/L.

<table>
<thead>
<tr>
<th>Type of Restaurants</th>
<th>Number of Systems in Group</th>
<th>Average BOD mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food/Burgers</td>
<td>6</td>
<td>974</td>
</tr>
<tr>
<td>Pizza</td>
<td>1</td>
<td>1856</td>
</tr>
<tr>
<td>Chinese</td>
<td>4</td>
<td>1364</td>
</tr>
<tr>
<td>Mexican</td>
<td>9</td>
<td>1254</td>
</tr>
<tr>
<td>American</td>
<td>1</td>
<td>1063</td>
</tr>
<tr>
<td>American Buffet</td>
<td>1</td>
<td>792</td>
</tr>
<tr>
<td>Steakhouse</td>
<td>2</td>
<td>601</td>
</tr>
<tr>
<td>Seafood</td>
<td>3</td>
<td>555</td>
</tr>
</tbody>
</table>
Most restaurants in the study had BOD’s in the 800-1000 mg/L range

Some types of food produced higher BOD’s like Mexican and Chinese

A menu review would be helpful when sizing a system
  - Sauces, sweets, etc.
  - Alcohol service
  - Grease

Practices in the facility are good to know too
  - Single service versus full plate service

Sampling of actual facilities
  - Take more than one sample just after busy periods
BOD Strength

- Rely on studies like Lesikar’s, menu review, sampling, and experience to make an assumption.
- If you don’t have the experience there are those that do and you should contact them!
Providing guidance to restaurant owners on how to help their systems work better

Working with the restaurant inspection team to let them know there is an onsite system there
Flows

- Often times dictated by regulation and conservative
- You may be able to assume a lower BOD value (10-30%) if the flows dictated are based on higher flow fixtures
- Most restaurants will never reach design flows, especially on a daily basis
- Actual flows are helpful if it is a chain restaurant or if there is a similar restaurant
- If flow equalization is in the plan then average flows taking into account the days and hours of operation can and should be used
Designing a treatment train

- It takes more than just a septic tank.
- Grease interceptors/traps
- Flow Equalization and Dosing
- Supply enough oxygen to meet the pounds of BOD₅ requirement as well as to treat excess FOG.
- Can this be done with a larger drainfield?
Soil treatment

- Soil properties vary
- Some soils cannot handle high BOD$_5$ loadings period. Silty Sands or Clays are examples.
- **IF** a soil can treat the wastewater the footprint could be very big and sometimes the land is not there.
- Multiple fields are a good option
- Seasonal facilities may work better
- Very high BOD’s and/or high FOG the soil is not a good medium for treatment.
If soil won’t work...then what?

- Add treatment equipment
- Treatment adds air to the wastewater in some fashion to provide the necessary oxygen to treat the wastewater.
- Partial treatment vs. full treatment
- When using treatment proper sizing and a maintenance and monitoring plans are key.
Treatment systems are not magic

- Cannot size by flow alone
- Fairly complicated process to evaluate a system for treatment from scratch.
- Designers should choose and regulators should require a system with a significant history treating high strength wastewater
- Splitting flows to multiple systems is difficult so choosing systems that make treatment in as few of boxes as possible is best
It’s time to use that algebra you never thought you would use!

“Algebra class will be important to you later in life because there’s going to be a test six weeks from now.”
ALL designs should characterize both flow and BOD strength to size the system!

These two numbers together are used to determine the total BOD load expressed in pounds per day.

This number represents what needs to be treated with oxygen.

Formula for BOD loading is:

\[
\text{Flow (gpd)} \times \text{Influent BOD (mg/L)} \times 8.34 = \frac{\text{lbs/BOD/day}}{1,000,000}
\]
Example

- An American restaurant with actual peak flow of 1200 gpd and a sampled influent BOD value of 825 mg/L

\[
1200 \text{ gpd} \times 825 \text{ mg/L} \times \frac{8.34}{1,000,000} = 8.26 \text{ lbs of BOD/day}
\]

- This value is critical to the evaluation...this is what needs to be treated.
How do we treat it?

- To treat 1 pound of BOD it takes an average of 1.2 pounds of dissolved oxygen.
- To treat 8.26 pounds of BOD we calculate this way:
  
  \[ 8.26 \text{ lbs of BOD} \times 1.2 \text{ lbs of } O_2 = 9.9 \text{ lbs. } O_2/\text{day} \]

- This is the Actual Oxygen Transfer Rate or AOR - we will talk more about this.
- Next step is to determine the aeration capacity of a proposed pre-engineered system.
Standard Cubic Feet per Minute (sCFM)

- Looking for the sCFM of the proposed aeration device.
- Can be determined by the spec sheet or contacting the aeration device manufacturer.
- An actual drawing with dimensions of the proposed unit is also needed to get the depth of the air release point.
  - If the drawing does not specify this then the manufacturer should be consulted.
Aeration Capacity

- Treatment units typically treat with fine bubble or course bubble diffusion and this should also be available through the manufacturer.
- The **EFFICIENCY** of the aerator is a function of the air release depth and the type of aeration (coarse or fine bubble).
Oxygen Transfer Efficiency (OTE)

- The air release depth and the type of aeration will give you the OTE
  - Course bubble diffusion = max 0.75%/ft
  - Fine bubble diffusion = max 3.0%/ft
- So now you have:
  - Design loading
  - sCFM for the aeration device
  - the release depth from the drawing or manufacturer
  - And the OTE which is standard in the industry and based on the type of aeration as listed above
- With these you can determine the Standard Oxygen Transfer Rate or SOR
Standard Oxygen Transfer Rate (SOR)

- The SOR is how much oxygen can be transferred into clean water at standard conditions by the aeration device being evaluated.
- SOR is measured in pounds per hour or pph.
- The calculation is done as follow:

\[ \text{SOR in pph} = 1.035 \times \text{sCFM} \times \text{OTE} \times \text{air release depth} \]

- Taking this by 24 hours in the day will give you the SOR in pounds per day (ppd).
- The SOR can then be used to determine the Actual Oxygen Transfer Rate (AOR) of the aeration device.
Back to Actual Oxygen Transfer Rate

- The AOR is $= k \cdot SOR$
  - $k$ = constant for efficiency of the aerator in sewage versus clean water
  - $k$ for fine bubble diffusion is between 0.4 and 0.45
  - $k$ for coarse bubble is between 0.5 and 0.6
- The AOR divided by 1.2 = the pounds of BOD that can be removed per day by that device.
Back to the example....

- American restaurant 1200 gpd producing 8.26 lbs/day of BOD
- Let’s put a fictitious 500 gpd suspended aeration system to the test...knowing you will need 3 to meet the flow requirement.
- A fine bubble diffusion system:
  - The AIR RELEASE DEPTH per the fictitious drawing is 66 inches or 5.5 feet.
  - The aeration system produces 0.49 sCFM at that depth per the aerator manufacturer
Here comes the algebra...

SOR in pph = 1.035 \times sCFM \times OTE \times \text{air release depth}

OTE is a constant for certain types of aerators
Fine bubbles maximum is 3.0%/ft

SOR in PPH = 1.035 \times 0.49 \times 3.0\% \times 5.5 \text{ ft} = 0.084 \text{ pph}

SOR in PPD = 0.84 \text{ pph} \times 24 \text{ h/d} = 2.02 \text{ ppd}
AOR = kSOR

k is a constant....for fine bubble between 0.4 and 0.45

AOR = 0.4 * 2.02 ppd = 0.81 ppd
Removal Capacity

BOD removal capacity = AOR/1.2 lbs O₂/lb of BOD

0.81ppd/1.2 = .675 ppd

- This is how much BOD can be removed by a single 500 gpd fine bubble system.
- If we size based on flow alone we would need 3 of these to meet the flow rating.
- For three 500 gpd systems the BOD removal capacity is 0.675 ppd X 3 = 2.02 ppd BUT we needed to treat 8.26 lbs at this restaurant.
- We really need 12 units at least. Practical?
Sludge management

- Use the same system we just reviewed
- For every pound of BOD coming into the system about 0.6-0.7 lbs of sludge is produced
- Since the aerator was very efficient we will assume 0.7 lbs of sludge is produced per day

\[ 8.26 \text{ lbs BOD/day} \times 0.7 \text{ lbs of sludge/lb BOD} = 5.78 \text{ lbs of sludge/day} \]
Since activated sludge systems are completely mixed the sludge is suspended and mixed in the aeration chamber and measured by the MLSS reading in mg/L

MLSS determines treatment efficiency and also indicates when sludge needs to be wasted

Need to know the reaction chamber size and for this fictitious system it is 475 gallons/unit

Assuming we sized on flow alone and used 3 units that is 1425 gallons of sludge storage capacity

Convert lbs of sludge produced/day to mg/L

\[
5.78 \text{ ppd} \times \frac{1,000,000}{1,000} = 486 \text{ mg/L of sludge accumulating in the mixed liquor}
\]

\[
8.34 \times 1425 \text{ gpd}
\]
When to waste sludge

- If the system is producing 486 mg/L of sludge per day in 30 days that would be 14,580 mg/L of sludge in the MLSS.
- Treatment efficiency of activated sludge systems requires the MLSS to be between 3,000 and 5,000 or the sludge will start “bulking” or not settling and leave in the effluent.
- To maintain efficiency the sludge would need to be removed every 6 - 10 days.
- Very costly to pump out and be watched to assure MLSS stays in the right range.
- Even at half the loading the system is not sustainable
- Add more units? Back to practicality.
Conclusions

- Determining an accurate influent BOD loading/day is critical to design.
- Determining if a system specified can treat the expected loading in a sustainable way is critical to long term performance.
- Using systems proven and designed for high strength wastewater removal is something that can be done but it is not inexpensive.
- If the owner of a restaurant is presented with a system that will work and accepts the costs involved and that system is installed correctly and maintained it will last a long time and perform.
- If the owner is not prepared to accept the costs of a correct design as a cost of doing business then they should not be allowed to put in a substandard system that will ultimately fail and could damage the environment.