

## Why Choose Packed Bed Technology?

#### Recirculating Packed-Bed Filter vs. Activated Sludge



#### Our Presenter Bo Tucker

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Bo holds a Bachelor of Engineering degree in biosystems engineering from Auburn University. In his spare time, he enjoys being active outdoors and spending time with his wife and children.



## Overview

- Generalities of wastewater treatment
- Activated sludge treatment process
- Packed-bed filter process
- Operational comparison
- Application comparison



## **Wastewater Treatment**

- Food
- •Air
- •Time

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





## **Wastewater Treatment**

- Aerobic
  - Carbon compounds + microbes + oxygen =>

carbon dioxide + water + more microbes

- With free oxygen
- Nitrification
  - Occurs when carbonaceous load is diminished

#### Anaerobic

- Without free oxygen
  - Oxidant may be nitrate, sulfate, etc.
  - Digesters



## **Getting Oxygen to the Microbes**





## **Activated Sludge**



https://www.flickr.com/photos/essentialpublicradio/6926401145/



#### **Unit Processes of Wastewater Treatment**





## **Unit Processes for Activated Sludge**





## **Grit Removal/Primary Clarifier**





## **Aeration Chamber**

- Oxygen is introduced to aerate the reactor
- Mixed liquor
  - Aerated microbial mass maintained in suspension
  - Recycled sludge added
- Extended air
  - Sludge held longer
  - Increased sludge age
  - Nitrification



## **Secondary Clarifier**





## **Tertiary Treatment**

#### • Processes that follow the secondary clarifier

- Disinfection
- Phosphorus reduction
- TN reduction
- PH adjustment
- Discharge

# **Activated-Sludge Process Operation**

Aeration chamber

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- Mixed-liquor monitoring
- Correct balance of microorganisms to treat influent
- Sludge-age monitoring
- Return activated sludge (RAS)
  - Concentration of sludge returned to aeration chamber
- Waste activated sludge (WAS)
  - Wasted sludge to discharge
  - Drying, dewatering, disposal



## **Recirculating Packed Bed Filters (RPBF)**





# **Recirculating Packed-Bed Filter Process Description**

- Single and multiple pass
  - Dates to late 1800s
- Developed for small scale flows as supplementary septic system components
- Similar to trickling filters, but with lower loading rates and higher surface areas
- Media types
  - Sand/gravel
  - Peat
  - Foam
  - Textile (AdvanTex<sup>®</sup>)



# Recirculating Packed Bed Filter Process Description, cont.

- Media filters (RPBFs) ...
  - Secondary treatment units
  - Designed to follow primary treatment
  - Categorized as non-submerged, "fixed-film" treatment technology
  - Access to atmospheric oxygen



## **Primary Treatment**

- Septic tanks/primary clarifiers/lagoons
- Sized to hold wastewater for extended periods of time
- >50% BOD<sub>5</sub>
- Up to 70% TSS
- Fats/oils/grease (FOG) sequestering
- Mandatory



## **Typical PBF Recirculation Configuration**





#### **Fixed-Film Treatment**







## **Textile Offers Greater Surface Area**

- Textile is specifically engineered for WWT
- The more surface area, the more area for bacterial colonization
- The surface area is large enough that the microbial colonies do not grow in excess and slough



Sand G

Gravel



## Packed-Bed Filter Biofilms

- Oxygen is diffused from the air that fills the unsaturated voids into the effluent and biofilms. (Oxygen concentration in air ≈ 275 mg/L.)
- After the carbonaceous demand is met in the upper levels of the media, inorganic constituents such as ammonia (NH<sub>3</sub>) are reduced to nitrate (NO<sub>3</sub><sup>-</sup>) by autotrophic bacteria in the lower region of the media.





## Comparisons

- Variable flow, influent conditions
- Sludge/solids handling
- Operation and maintenance
- Power costs
- Advantages



## **Variable Conditions**

- Flow
- Waste concentrations
- Phased growth
- Seasonal conditions

# **Operation and Maintenance**

- Activated-sludge plants need almost constant operation.
  - Control food to microorganism ratio (sludge age)
  - Monitor settleability
  - Monitor flows

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- RPBFs require very little operation.
  - Solids held in large septic tanks
  - Self-regulating bio-mat
  - High levels of dilution



# **Sludge Handling**

• WAS

- Testing determines when sludge should be wasted
- Wasted sludge must be managed
  - Aerobic, anaerobic digestion
  - Drying beds, belt presses
  - Disposal

 RPBF systems only require septic tank, recirculation chamber pumping, 5-10 years



## Oxygen Availability in Air

≈ 275 mg/L oxygen in free air, which directly interfaces with the biomass ... in contrast to 9 mg/L DO holding capacity of water for oxygen transfer







## **Power Consumption**

#### Activated sludge

- Blowers
- Compressors
- Pumps
- Rotary arms, etc.
- RPBFs
  - Pumps
  - Vent fan



## **Maryland Study**

In 2009, President Obama issued an executive order to clean up the Chesapeake Bay.

Each state contributing (7 total) to the eutrophication of Chesapeake Bay, with the help of the EPA, put together Watershed Implementation Plans (WIPs).

Maryland, which collects a tax to publicly fund decentralized treatment systems, put together a testing program for various wastewater systems.



## **Maryland Study**

Maryland's third-party "Best Available Technology" field-testing requirement for nitrogen:

http://www.mde.state.md.us/programs/Water/BayRestorationFund/OnsiteDis posalSystems/Documents/HB347%20ranking%20data%2001072015%20 updating.pdf

Matrix shows cost/pound of TN removed, electrical consumption, etc...

PBFs were consistently ranked as the most cost-effective technology.



## **Comparing Treatment Performance**

Vendor In Ascending Order	Mean % Reduction TN (Using 60 mg/L Influent)	<i>Mean Effluent Concentration (Mg/L)</i>
AdvanTex AX20-RT	76%	14
AdvanTex AX20	71%	17
SeptiTech M40D	67%	20
Hoot BNR	64%	21
RetroFast	57%	25
Singular TNT	55%	27
Singular Green	55%	27



## **Comparing Treatment Performance**

Vendor In Ascending Order	1 Year Electrical Consumption (represented as KWh/ year)	Increased Electrical Costs Per Year Assuming \$0.11 Per kWh
AdvanTex AX20	335.8	\$36.94
AdvanTex AX20-RT	335.8	\$36.94
Hoot BNR	765.77	\$84.23
Singular TNT	979.66	\$107.76
Singular Green	979.66	\$107.76
SeptiTech M40D	1934.50	\$212.80
RetroFast	2584	\$284.24

# **Advantages of Each Technology**

#### RPBF Pros

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- Consistent high-quality treatment
- Limited operator involvement
- Low power costs
- Able to handle seasonal or increasing flows
- Excels in lower flow application
- Comparatively easy expansion
- BOD<sub>5</sub> and ammonia reduction
- Works exceptionally well with effluent sewers

- Activated Sludge Pros
  - Quality treatment with good operator
  - Relatively compact footprint
  - High flow capacity
  - Operational options



# **Technology Comparison Conclusion**

- <u>Recirculating Packed Bed Filters</u>
  - Prime option for decentralized treatment
  - For applications where operational and power costs need to be low
  - Provides consistent treatment even when flow rates and influent waste strengths are not
  - Consistent operation not necessary
- <u>Activated Sludge</u>
  - For large scale system or municipalities
  - With competent operation, can achieve high-level treatment for multiple conditions



## Summary

- Understand the requirements of the system for the waste stream
- Understand the requirements of the end user for the system chosen
- Consider life cycle costs



#### **Solutions for Decentralized Wastewater Treatment**

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