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EEVOLVED™ MBBR

MBBR Design Considerations and Case Studies

Inside this presentation

Basic MBBR Design

- What is MBBR and its Benefits?
- MBBR Design 101 (Domestic)
- Biofilm Carrier Selection

Case Studies

- Textile
- Dairy

Industrial Considerations

- Slaughter-House
- Food and Beverage
- Pulp and Paper
- Fishery

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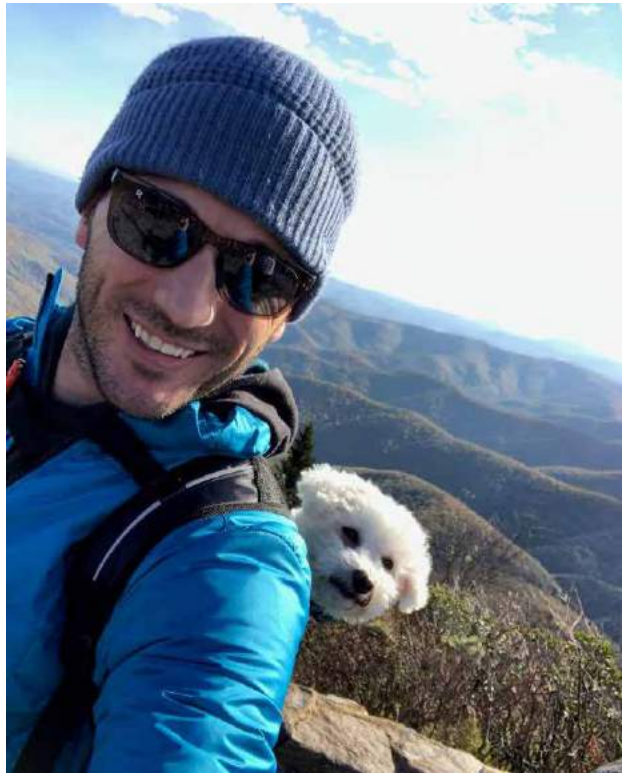

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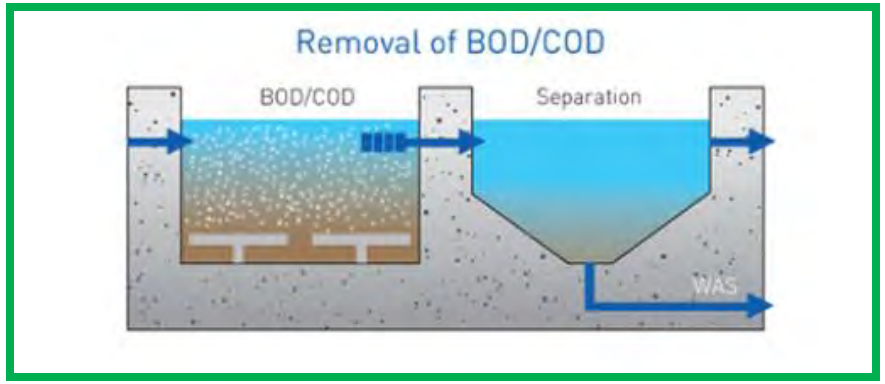
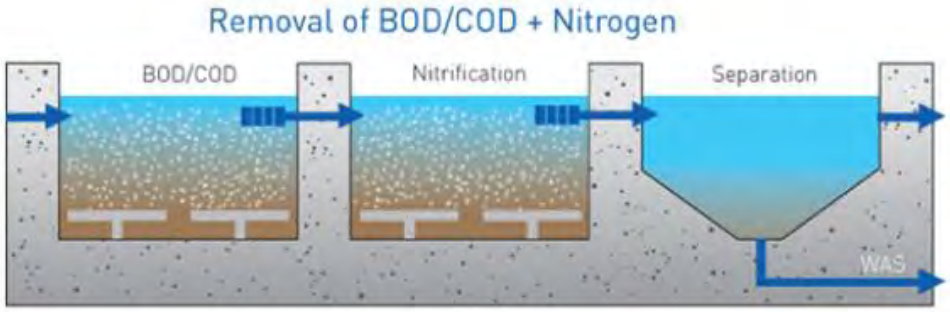
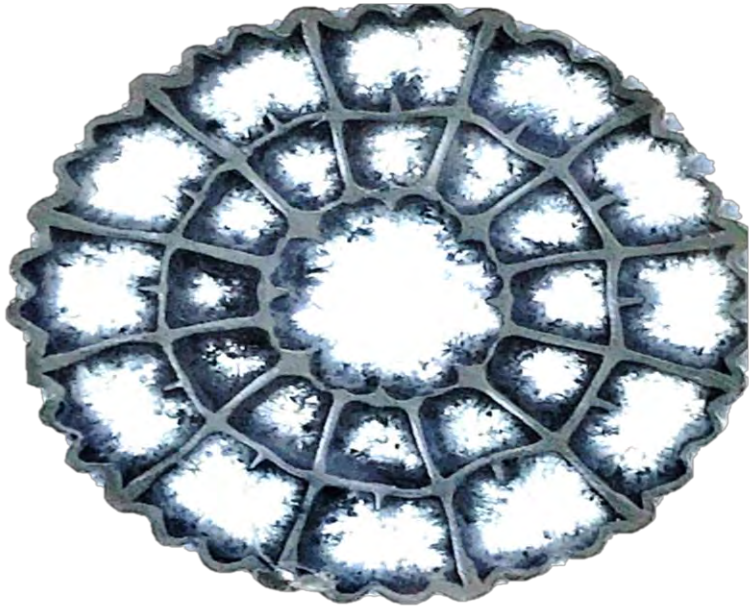
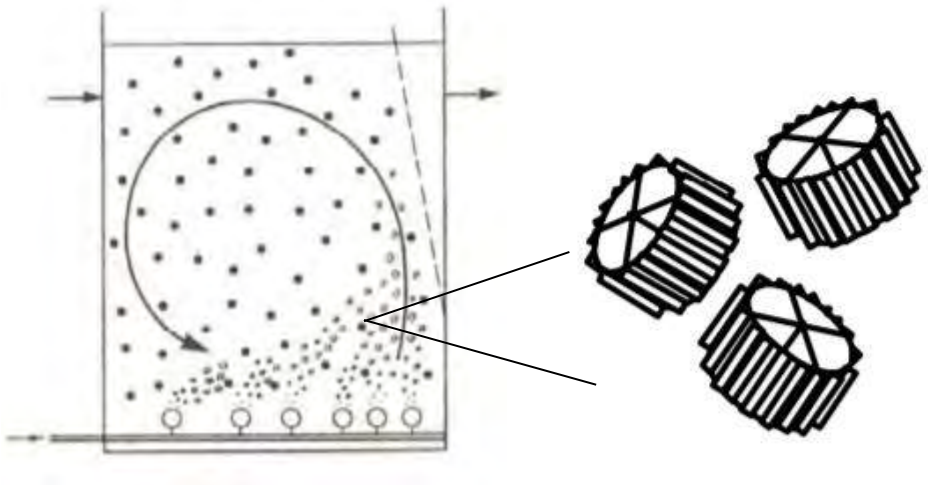
MBBR 101


Removal of BOD/COD
BOD/COD
Separation
WAS


Removal of BOD/COD + Nitrogen
BOD/COD
Nitrification
Separation
WAS



MBBR History



"Father of MBBR"

- Professor Hallvard Odegaard
- Norway, late 1980's

Historical Design

- Coarse Bubble
- More Conservative HRTs
- Simple, low surface area media

Innovation in MBBR

Advancements in Fine Bubble Technology

Mixing Patterns, Efficiency, and Maintenance

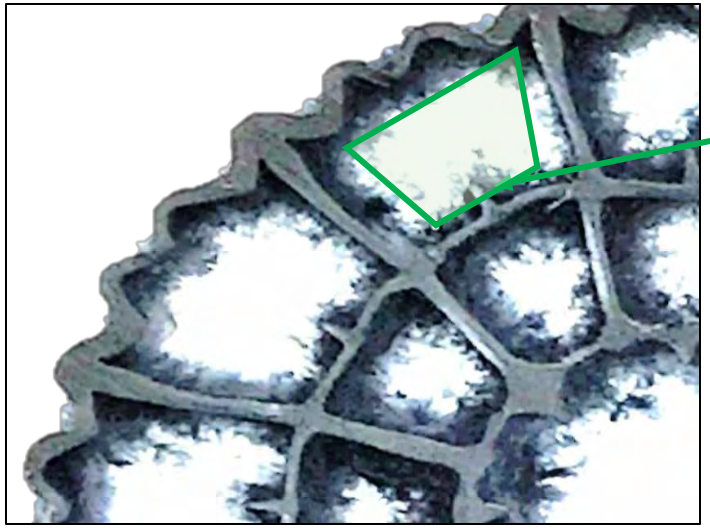
Advancements in Media Development

Optimizing materials and geometries

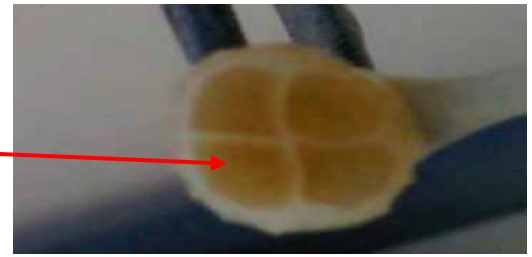
Continuous Research and Advancements in Design

Mapping DNA, exploring EPS, and simultaneous treatment with biological layering

So what is a healthy MBBR system?



High % open area
Optimized diffusion area
Optimal biofilm control
Consistent and stable treatment
Optimal Diffusion ~ 200 microns



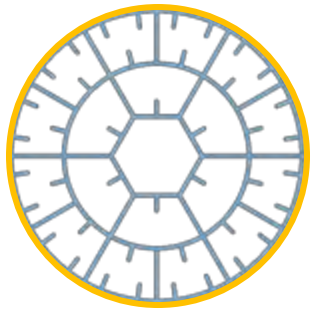
Loss of internal diffusion
Lower efficiency
Reduced organic removal rate

Uniform Distribution
throughout Tank

How do we design an MBBR System?

1. Define the Problem/Project
   - Understand the specific water chemistry
   - Ensure the system will be a fit for biological treatment
2. Find the Volume of Media Needed
   - Based on the treatment requirement
3. Design the Reactor Configuration
   - Media must be 30%-65% fill
   - Aeration System
   - Media Retention Screens

How do we design an MBBR System?



Protected Surface Area (PSA)

Area for Biological Growth

Primary Requirements

- Surface Area Loading Rate*
- Surface Area Reduction Rate*
- Constituent Loading into MBBR
- Effective Surface Area
- Required Treatment (% removal)

From Influent Data into MBBR

$$\frac{Daily\ Load}{SALR} = Required\ (total)\ Media\ SA$$

SARR

PROJECT SPECIFIC

$$\frac{Required\ Media\ SA}{Protected\ Surface\ Area} = Total\ Volume\ of\ Media$$

EFFECTIVE SURFACE AREA

From Media Selection

*Requires experience and project understanding

What is SALR?

Surface Area Loading Rate (SALR) is a measurement of the daily load across the total protected surface area

$$SALR\left(\frac{g}{m^2}\right) = \frac{Daily\ Load\ (\frac{g}{day})}{Total\ PSA\ (m^2)}$$

- Empirically derived over 30 years
  - Continuing development
- Impacted by the following factors:
  - Media Geometry
  - Biofilm Thickness
  - Predation
  - Diffusion (through the Media)
  - Biodegradability
  - Toxicity
  - Alkalinity and pH
  - Suspended Solids and FOG
  - **Temperature**

Does SALR actually indicate treatment?

To capture the treatment efficiency, we use Surface Area **Reduction Rate** (SARR)

$$SARR\left(\frac{g}{m^2}\right) = \frac{Daily\ Reduction\ (\frac{g}{day})}{Total\ PSA\ (m^2)}$$

Typical (domestic) treatment efficiency is ~90%

Therefore, SARR = ~90% * SALR

As SALR exceeds ~20 g BOD/m^2, efficiency drops to 70-80%

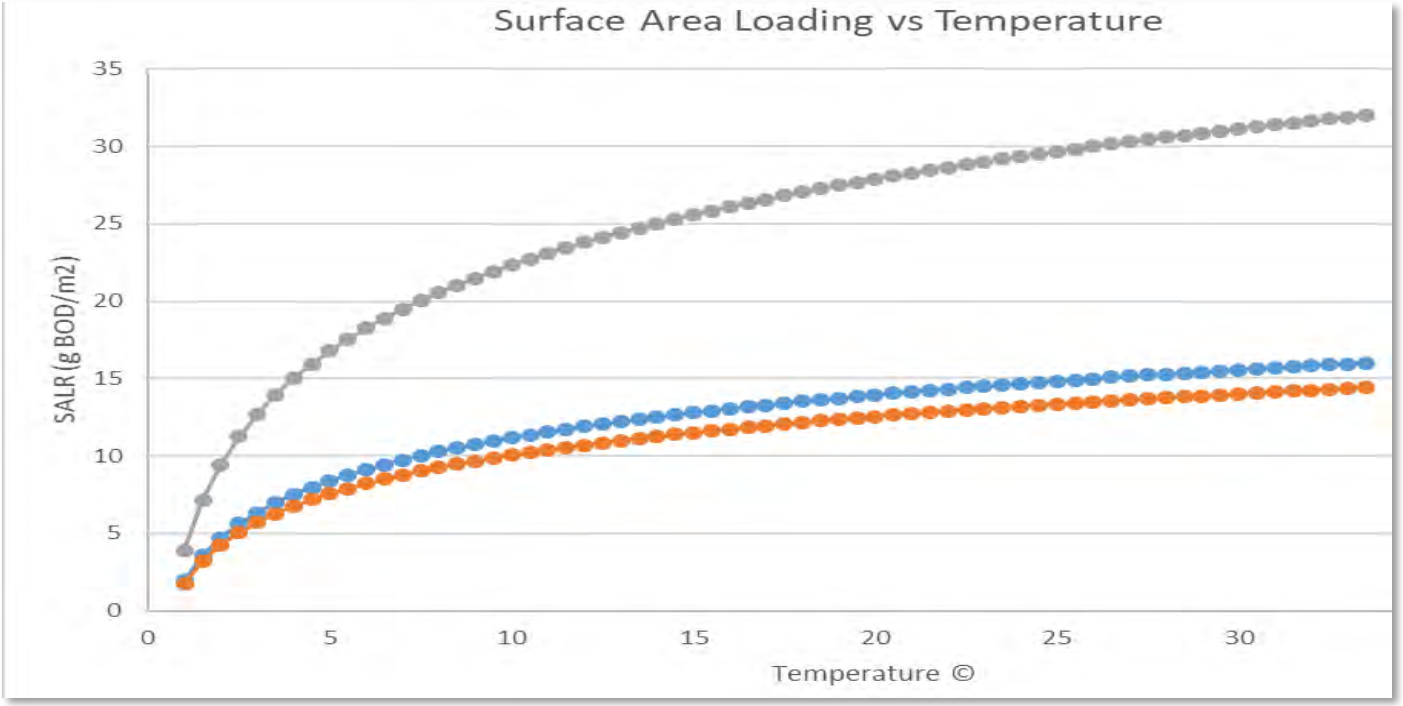
Technically, we are only reducing the *soluble* fraction of BOD.

Particulate BOD is normally separated in primary or clarifies. It requires longer assimilation.

How can we estimate SALR?

- **No universal equation for SALR**
- SALR inversely correlated to % removal
  - Usually ~90% removal
- SALR directly correlated to temperature
- SARR inversely correlated to SALR

- Graph SALRs vs. Temperature
  - Logarithmic correlation
  - Different industries
  - Different medias

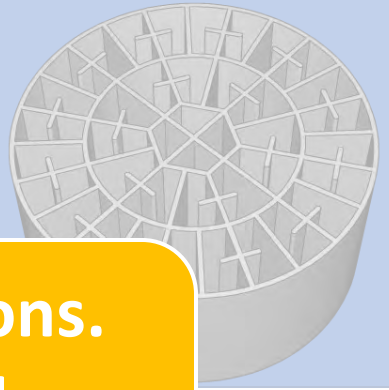


Extrapolating an SALR/SARR for a K_1 media to a High SA Media…

SARR

How much can treat with 1 m^3 (

≠



Pay Careful Attention to Studies and Equations. Which Type of Media and Wastewater are they Based on?

How far can you go with 1 tank of gas?

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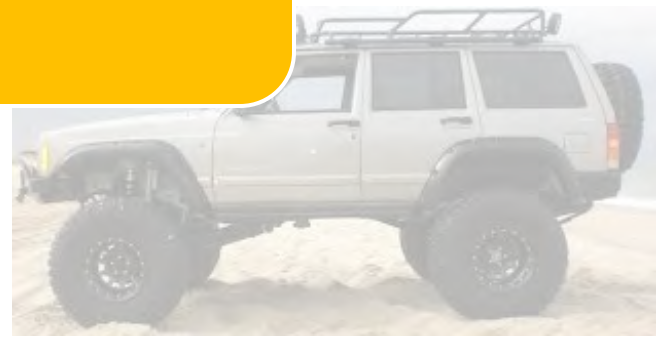
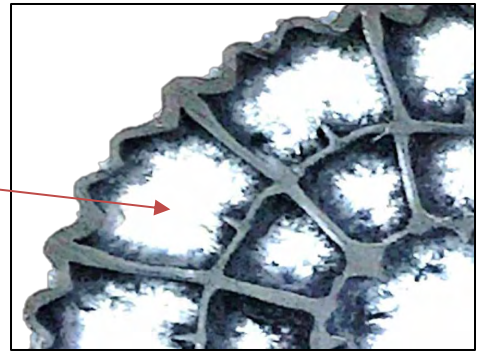


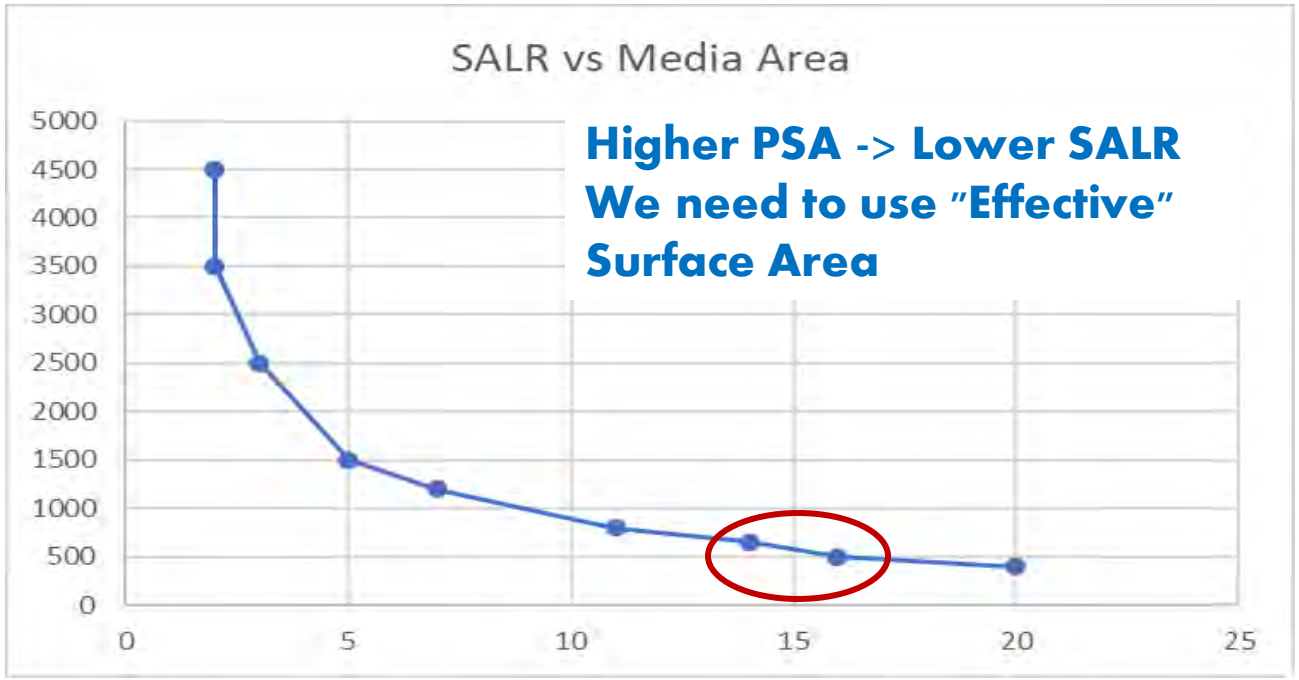
…Is like extrapolating an MPG for a Honda Fit to an Old Jeep

MEDIA IS ENGINEERED, NOT PLASTIC

Proper MBBR Media Design is Imperative

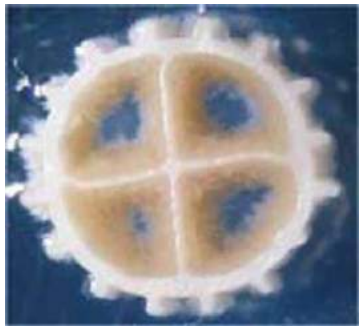
- High % open area
- Optimized diffusion area
- Optimal biofilm control
- Consistent and stable treatment





Examples of:

Loss of internal diffusion
Lower efficiency
Reduced organic removal rate



Selecting the Right Media

Material Properties

Each Media is DIFFERENT

- Hydrodynamics
  - How the media moves and distributes
- Loading Rates
  - 2 – 20 g BOD/m2 (10x difference)
- Mixing Energy
  - 5 – 25 Sm3/hour-m2 (5x difference)
- Strength and Longevity

Surface Area Is Not The Most Important Characteristic

Modeling only accounts for SA

↓

"Space Race" for high SA

↓

Not Enough Media

↓

Failed MBBRs

Selecting the Right Media

Material Properties

HIGH QUALITY VIRGIN HDPE

- Wall Thickness
- Geometry
- "Effective" surface area
- Specific Gravity
- Wet Time
- Mixing
- Strength (property of HDPE material)

It takes a fine balance of these objectives to create a good media

How can we estimate SALR for waters other than domestic?

Research, experience, and a holistic understanding of the wastewater system

Remember all those factors that impact SALR?

We need to consider all of those for each project

Negative Impacts on SALR

- High COD:BOD (>2:1)
- Low Biodegradability
- High TSS:BOD (>1.5:1)
- High FOG (>20mg/L)
- Toxicity
- Low Alkalinity
- Too high or too low pH (6.5-8)

Holistic Design

It all impacts the MBBR

Pretreatment!

Fraction of insoluble/soluble BOD directly impacts primary and tertiary treatment

FOG, suspended solids, etc. can all impact SALR.

Example: investing in advanced screening could reduce MBBR by ~30%

Primary Treatment
- Screening
- Grit Removal
- Oil/Water Separation
- Primary Clarifier
- Equalization

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Secondary Treatment
- MBBR
- Clarifier

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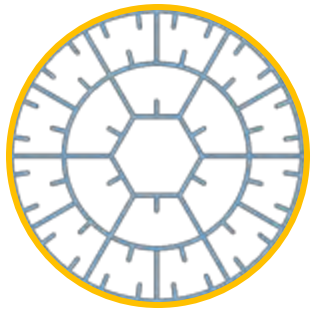
Tertiary Treatment
- Filtration
- UF/RO
- Disinfection

Review



Effective Surface Area (ESA)

Area for Biological Growth

Primary Requirements

- Surface Area Loading Rate*
- Surface Area Reduction Rate*
- Constituent Loading into MBBR
- Effective Surface Area
- Required Treatment (% removal)

BOD Reduced in MBBR

$$\frac{Daily\ Load}{SARR} = Required\ (total)\ Media\ SA$$

SARR = Efficiency * SALR

PROJECT SPECIFIC

*Requires experience and project understanding

$$\frac{Required\ Media\ SA}{Effective\ Surface\ Area} = Total\ Volume\ of\ Media$$

From Media Selection

Why can't we use the equivalent method?

Conventional activated sludge (CAS) systems rely on MLSS (suspended phase biology)

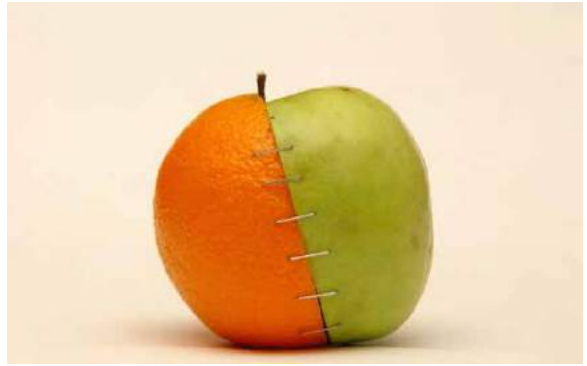
- Predicting the "mass of biology on the media" is too inaccurate

Models are inaccurate

- Models assume more biomass = more treatment
- In MBBR, thicker biomass ≠ more treatment

  Optimal Diffusion in Aerated MBBR is 200 microns so going to 1mm of biomass does not directly correlate to "more treatment"

These are DIFFERENT systems …



MBBR Aeration Design
Diffuser Selection

- 2mm PTFE Discs with full floor coverage
- Greater resistance to foul and creep
- “Medium bubble” for more mixing energy
- Better turn up/down flexibility
- ~30% energy savings compared to coarse bubble