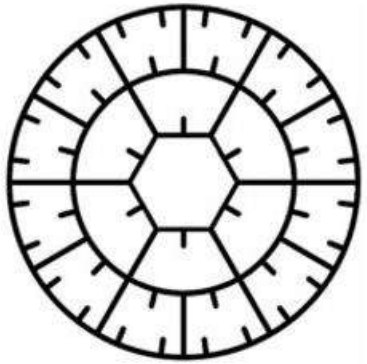
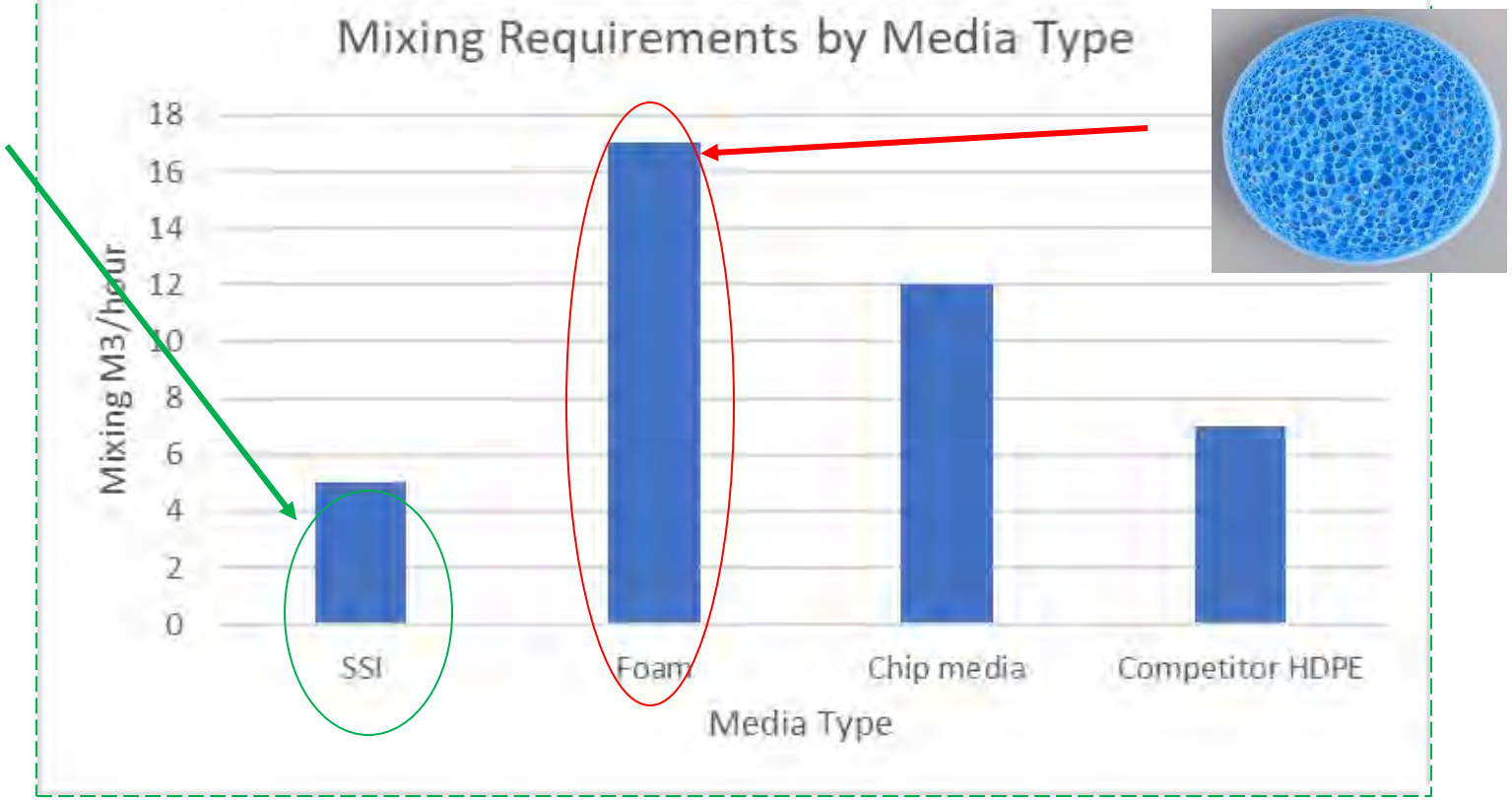
MBBR Aeration Design
Mixing Energy



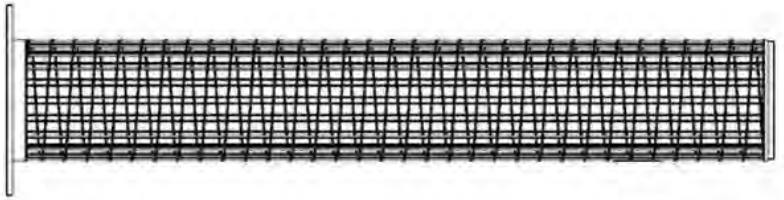
Minimum mixing for biofilm carrier dispersion

Different material properties and shapes require differing amounts of energy. SSI's MBBR is designed to use lowest energy compared to competitor MBBRs



- Slot size should be < 70% of the smallest dimension of the biofilm carrier
- Wedge wire –
  - Larger % open area
  - Reduces headloss and slot velocity (preventing media from moving towards the screens and building up)
  - Design based on peak flow
- Place above aeration grids to keep energy high energy
- Primary screen should be smaller to prevent solids buildup

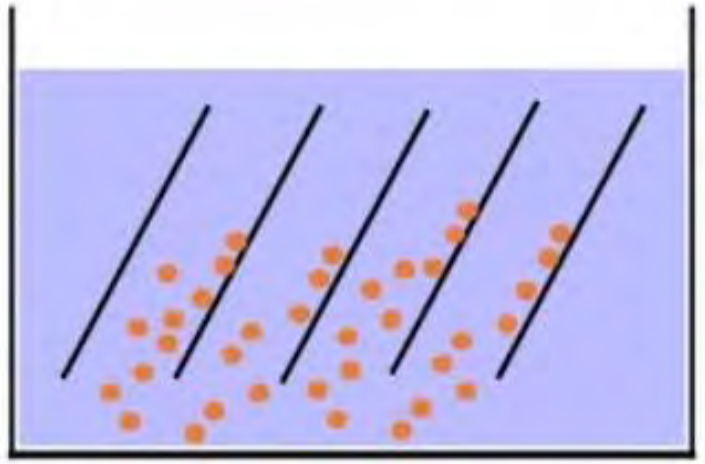
Media Retention Screen Design



Post-MBBR Clarifier Design

- Rapid clarification
- Solids are smaller (will be even smaller with coarse bubble) and therefore take longer to settle

  -> Reduce settling distance
- But if retention time is too high, system can start to denitrify, creating gas and issues with settling
- Surface overflow rate (SOR) is typically between 1.0-2.5



Industrial Considerations

Thinking holistically

Design Considerations
Slaughter-House

What is different?

- High levels of COD and iron
- High levels of:
  - Proteins
  - Coliforms
  - Lard, oil and grease
- Higher viscosity and density
  - Stratification of liquids
- Hair, meat, and other organic material

How does that impact design?

- Requires advanced Primary Treatment
  - Screening
  - DAF
  - Oil/Water Separators
  - Primary Clarifiers
  - pH adjustment for precipitation
- Septic conditions
  - Proper aeration design
  - 1.2 to 1.4 kgs O_2/kg BOD
- MBBR: SALR will be impacted by mineral and inorganic fouling
  - Typical BOD SALR: 7-10 g/m2-day

Design Considerations
Fisheries (processing or farming)

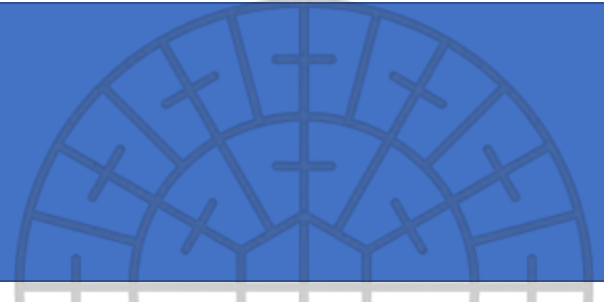
What is different?

- High FOG
- Nitrates (salting/smoking process)
- High proteins/amines
- Alkalinity control
- Temperature
  - Lagoon or pond treatment typical
- Threshold for toxicity
  - Requires low ammonia effluent

How does that impact design?

- Performance is crucial
- Careful pH control
  - High pH -> Free Ammonia (Toxic)
- Alkalinity Addition
  - Alkalinity required for Nitrification
- Oil/Water Separation
- Usually have side-stream MBBR
- Typically have higher HRTs and reduced SALRs
  - Typical BOD SALR <9 g/m2-day
  - Typical TAN SALR <1 g/m2-day

Design Considerations
Food and Beverage



What is different?

- High BOD and COD
- Usually Biodegradable
- pH, Calcium, and inorganics (salts) can be challenging
- Micronutrients (Mg, Ca, Zn)
- High TDS (color, sugars, salts)
- Ca^{+} and PO_4 issues
- High Specific O_2 Uptake Rate
- Nutrient deficiency

How does that impact design?

- Salinity and TDS
  - Impact Oxygen saturation
  - Impact transfer efficiency
- Higher biodegradability -> higher SALR
- Watch for potential Calcium Phosphate
- Typical BOD SALR: 10-16 g/m2-day

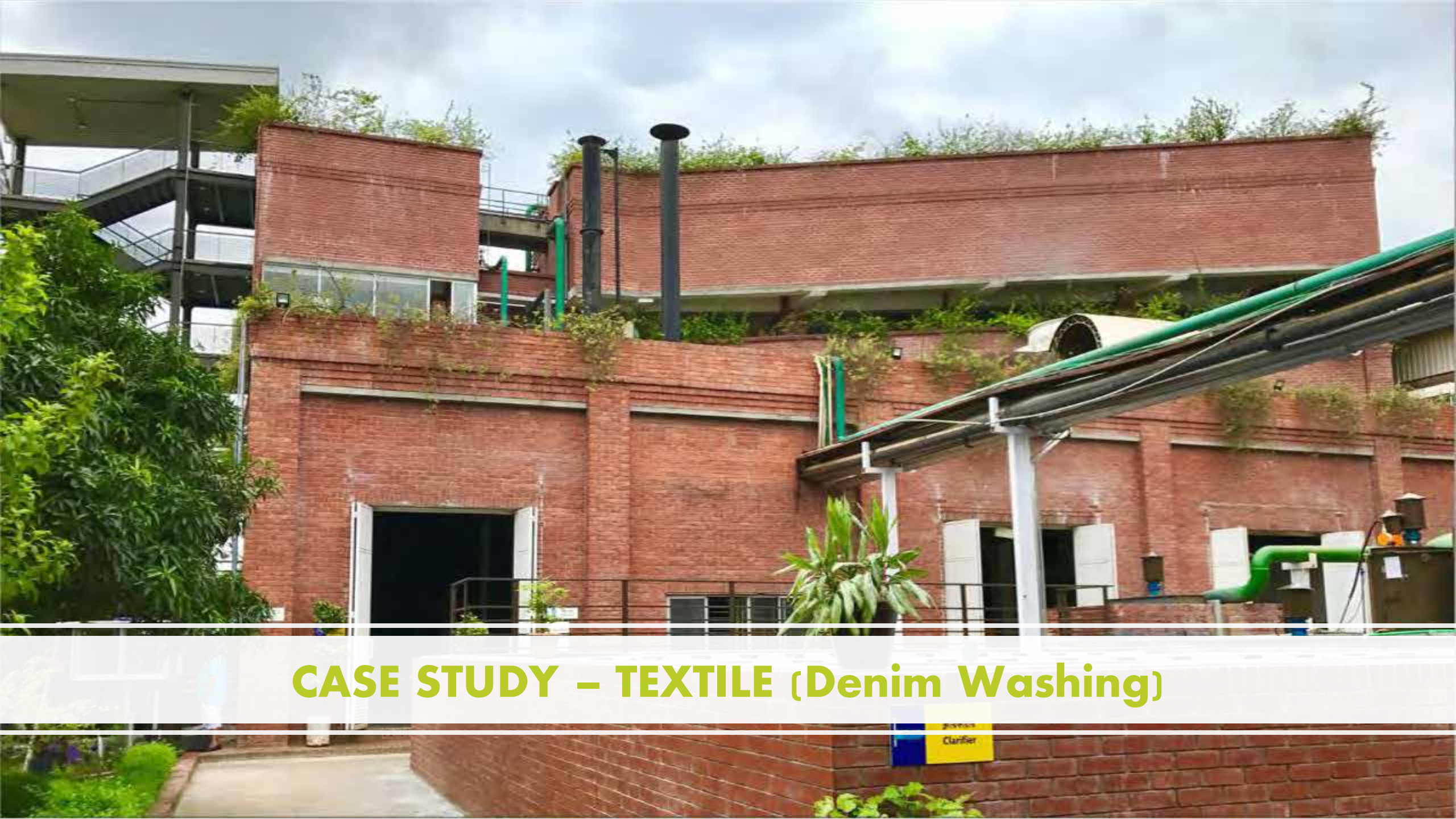
Design Considerations
Pulp and Paper

What is different?

- High levels of Organic matter, Calcium
- Alkaline
- Glues and Chemical Bleaching
- High Temperature**

How does that impact design?

- MBBR normally used as pre-treatment step
  - 50-70% removal by design
  - SALR 12-25 g BOD/m2-day
- Calcium Phosphate and Struvite (Magnesium Ammonium Phosphate) Buildup
  - Reduced SALR
- Carbonic Acid Build up
  - Negatively impacts biological metabolism and creates filamentous growth in clarifier

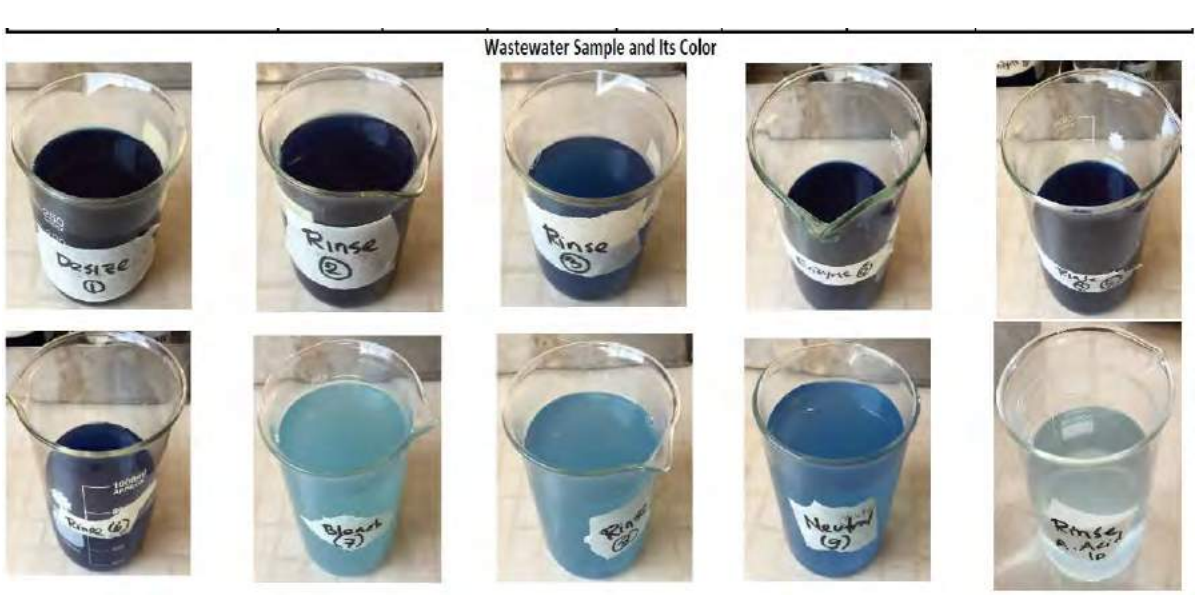


CASE STUDY – TEXTILE (Denim Washing)

Let's talk industry. Textile chemistry

- Production of textile includes many manufacturing disciplines:
  - spinning, weaving, knitting, wetting and garment manufacturing
- ~72% of water consumption from chemical "wetting" processes
- Wet processing includes
  - water
  - dye
  - inorganic + organic chemicals
  - detergents + soaps
  - finishing products
- Wet processing of denim involves:
  - Desizing – removal of starch (amylase treatment)
  - Stone washing – cellulase treatment (worn appearance)
  - Bleaching + neutralization – color preparation
  - Fabric softening

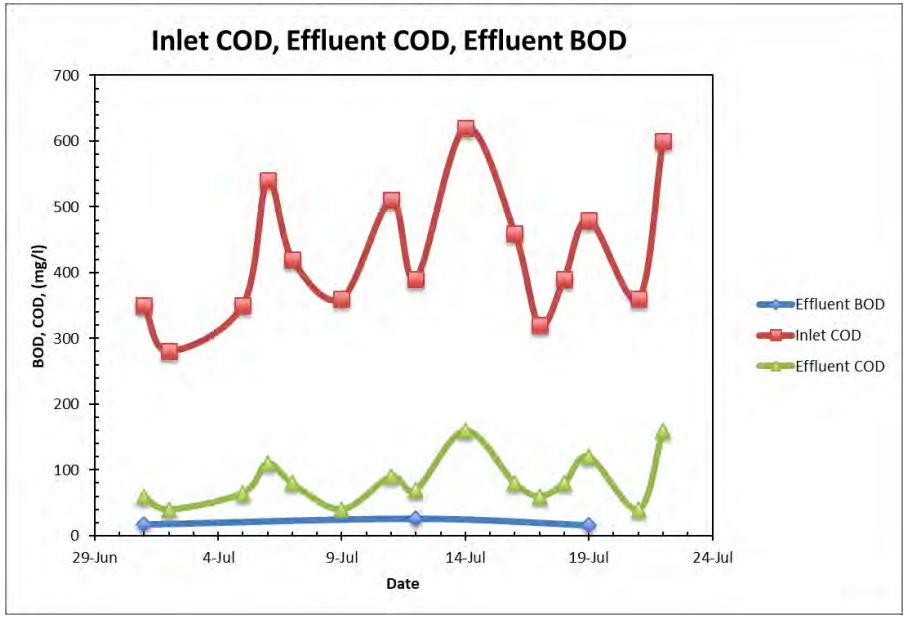
Process	Composition	Nature
Sizing	Starch, waxes, carboxymethyl cellulose, polyvinyl alcohol.	High in BOD & COD
Desizing	Starch, waxes, carboxymethyl cellulose, polyvinyl alcohol.	High in BOD, COD, suspended solids, dissolved solids.
Scouring	Caustic soda, waxes, grease, soda ash, sodium silicate, fibres, sulfactants, sodium phosphate.	Dark colored, High pH, COD, dissolved solids.
Bleaching	Hypochlorite,Caustic soda, sodium silicate, hydrogen peroxide, sulfactants, sodium phosphate.	Alkaline suspended solids.
Mercerizing	Caustic soda.	High pH, low COD, high dissolved solids.
Dyeing	Various dyes, mordants, reducing agents, acetiv acid soap	Strongly colored, High COD, dissolved solids, low SS
Printing	Pastes, starch, gums, oil, mordants, acids, soaps.	Highly-colored, High COD, oily appearance, SS
finishing	Inorganic salts.	Slightly Alkaline, low BOD.

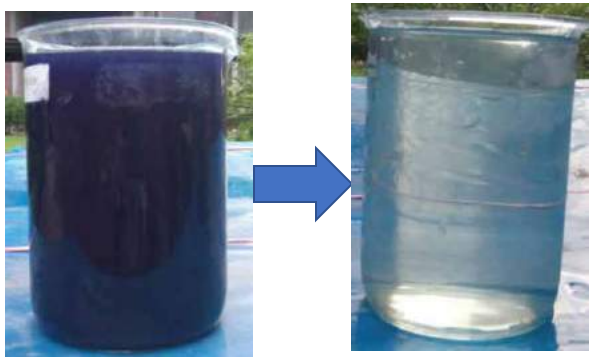


Highlights

- Denim Washing + Dyeing Effluent Treatment Plant (ETP) upgrade to 150 m^3/hour
- Upgrades included new screening, energy efficient aeration (PTFE Fine Bubble), MBBR system (HDPE carriers) + High Rate Tube Settler
- MBBR upgrade has successfully expanded ETP capacity while meeting **Bangladesh BSR effluent** for 2+ years.
- Road to Zero Hazardous Chemical Discharge (ZHCD) – MBBR upgrade has demonstrated ability to consistently reach **Aspirational levels** (COD, BOD, N, TSS)
- MBBR is a proven biological treatment method for Textile ETPs, demonstrating low energy consumption (**< 0.2 kWhr/m^3**)
- MBBR is not plastic. It is a **process**.
- Careful design allowed use of Advanced Biofilm carrier + **Fine Bubble Aeration** to produce low solids discharge
- MBBR uses minimum infrastructure and has high volumetric efficiency

GWL Bangladesh- 2015
3840 m3/day SSI MBBR for Textile Effluent



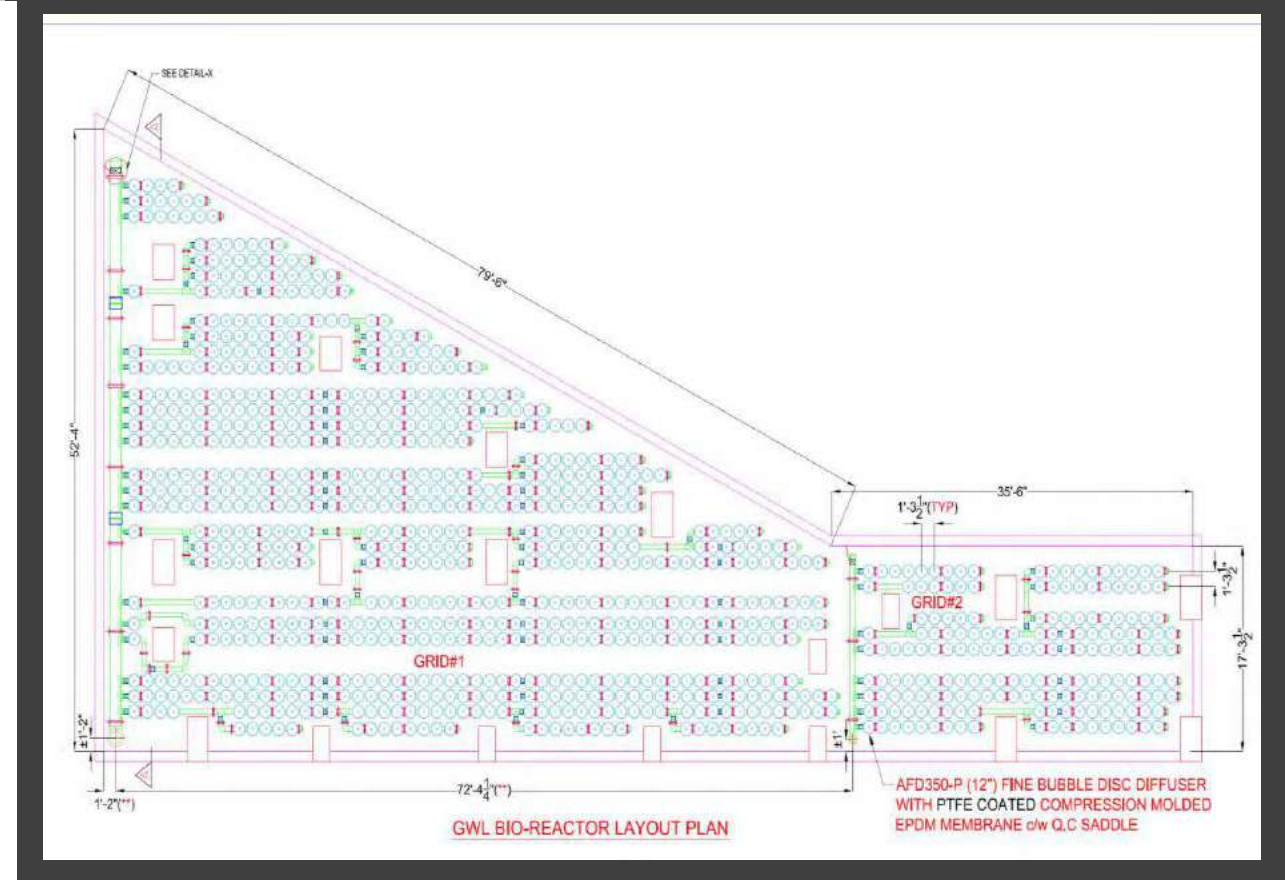


Design Objectives
Project requirements

- Biofilm Carrier Design
- Surface area
  - 650 m^2/m^3 @ 87% open area
  - Higher SA ≠ better treatment
- Specific gravity (Critical!)
  - 0.95 (+/- 10%)
- Material (Critical!)
  - Virgin HDPE w/ Carbon Black
- Media fill %
  - 33%
- HRT
  - 6 hours (900 m^3 @ 150 m^3/hour)

Screening + Grit

SSI



Aeration

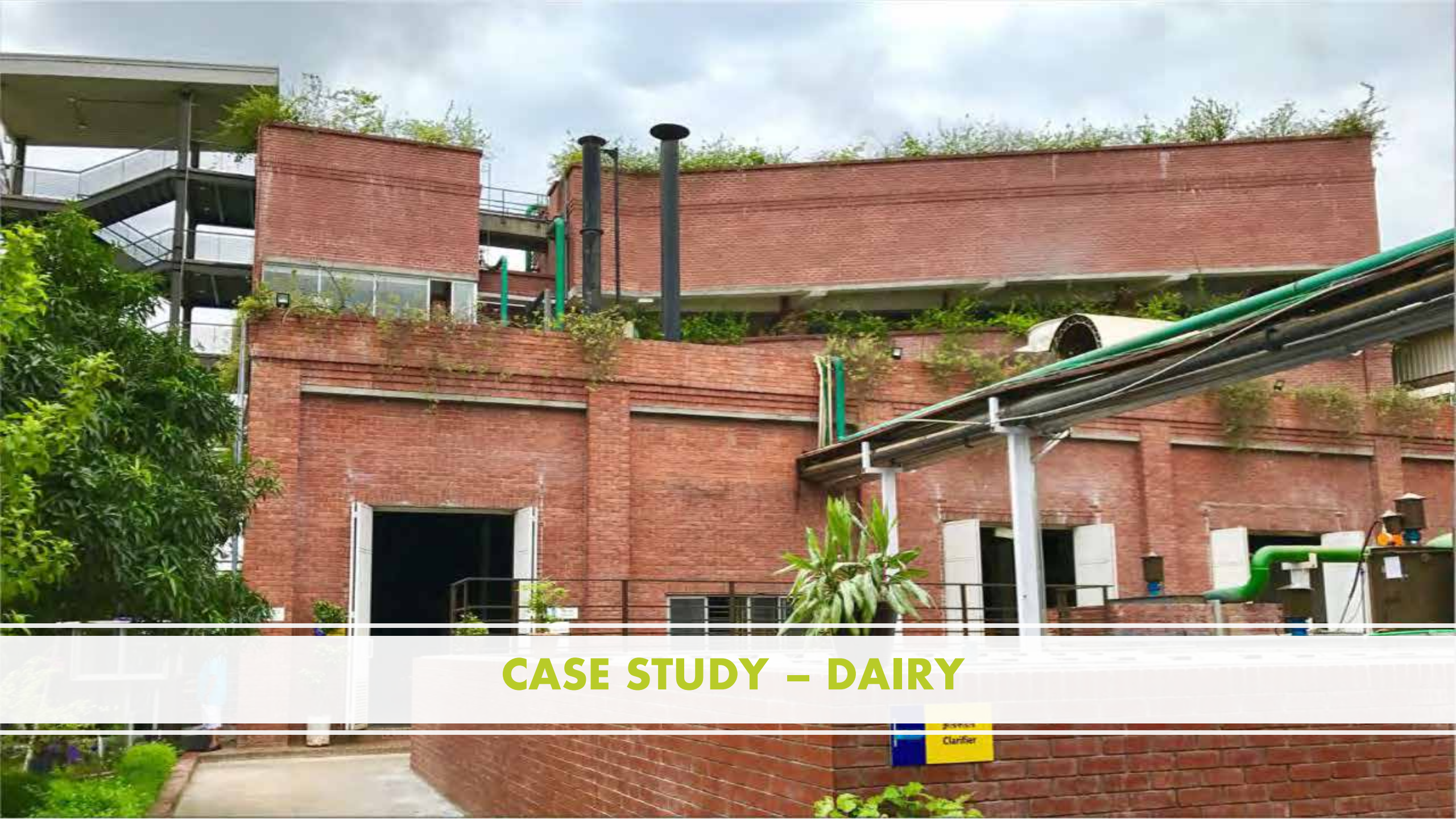
- PTFE 12-inch Fine Bubble Aeration
- Specialized Fine Bubble Aeration
  - PTFE Coating – Polytetrafluoroethylene
  - Preferred for textile

- 12-inch diameter – 2mm
- 1,800 kg BOD design (500 ppm)
- 293m2 plan area @ 20 m3/hr-m2
- 0.2 kWhr/m^3

- <u>High Rate Clarifier Design</u>
- 2 hour HRT
  - 300m^3 volume @ 53.69 m^2 plan area
- **99% Tube Media** Coverage
  - 60-degree @ 1.1m active depth
- Surface overflow rate (SOR)
  - 150 m^3/hour / 53.69 m^2 = **2.79 m/hour**
- Solids Loading Rate (SLR)
  - Design MBBR TSS discharge = 400 ppm (1,439 kgs/day)
  - 1,439 kgs/day / 53.69 m^2 = **26.81 kgs/m^2-day**
  - **Actual = 20.11 kgs/m^2-day**

Design Objectives
Project Requirements

SSI



CASE STUDY – DAIRY

Confidential Dairy

- 288 gpm
- 2-stage MBBR pre-treatment
- ~40% fill
- $BOD_{influent}$ ~ 3,000 ppm
- $BOD_{effluent}$ ~750 ppm

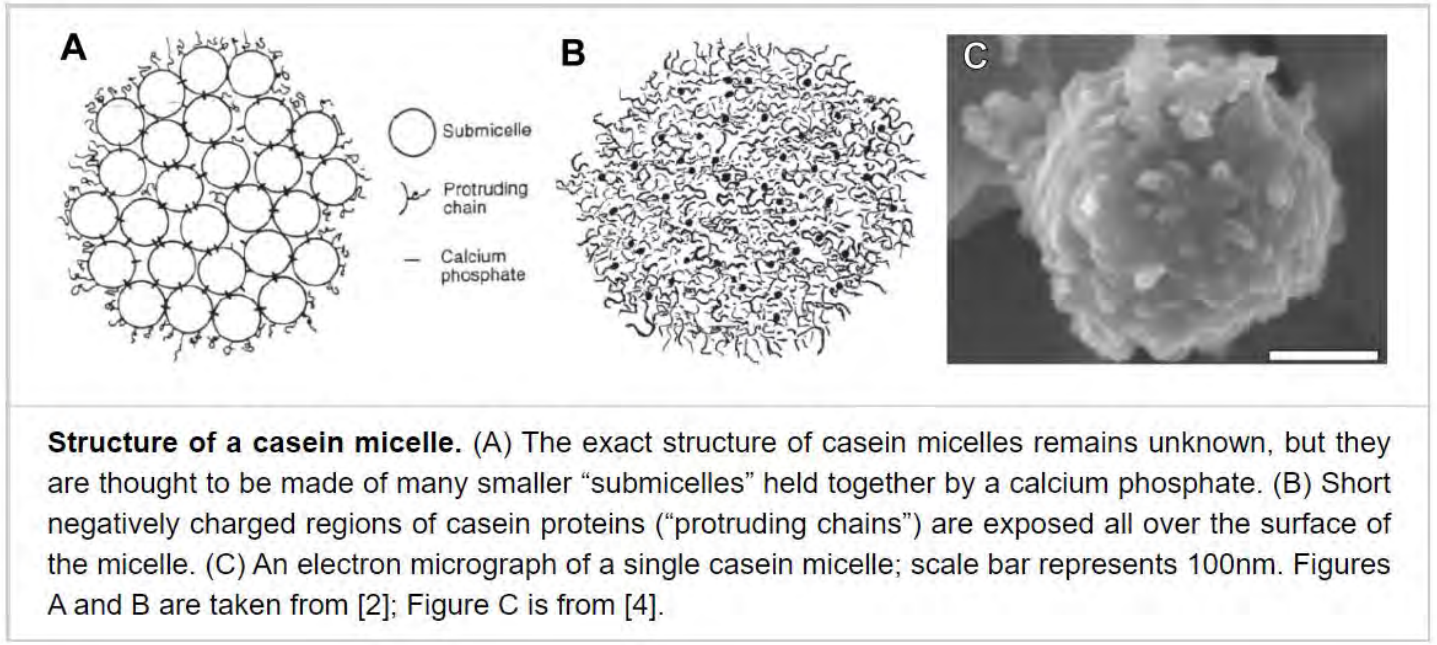
Design Considerations
Dairy

Dairy Chemistry

- Whey, Urea, Lactose
- Lipids, Proteins, Salts
- Enzymes, Casein, and Calcium

What does that mean?

- Every Dairy is different
- High organic loading
  - Nitrogen and Carbon
- Long chain amino acids
- Insoluble
  - Fatty Acids
  - Cellulose



Structure of a casein micelle. (A) The exact structure of casein micelles remains unknown, but they are thought to be made of many smaller "submicelles" held together by a calcium phosphate. (B) Short negatively charged regions of casein proteins ("protruding chains") are exposed all over the surface of the micelle. (C) An electron micrograph of a single casein micelle; scale bar represents 100nm. Figures A and B are taken from [2]; Figure C is from [4].

Design Considerations
Dairy Facilities

What is different?

- Production Variation = Large variance in COD Loads
- Most of BOD is Soluble
- COD:BOD is normally 2:1 or 3:1
- High levels of Calcium, Salt, Struvite, and FOG…

Whey Processing…

- Extreme COD & BOD
  - COD > 10,000 ppm

How does that impact design?

- EQ tank, instrumentation to sense and adjust aeration, nutrient dosing, and pH dosing during peaks
- Adjust MBBR SALR to account for potential inorganic fouling
- DAF operation typically preferred
- Use “calamity” tank is common
- MBBR SALR (as primary treatment)
  - 8-12g BOD/m2
- MBBR SALR (as pre-treatment)
  - 14-25 g BOD/m2-day

- Influent is basic -> Add H2PO4 acid
  - Calcium Phosphate Buildup

    OR
  - Calcium Hydroxide Buildup

  - DAFs work better with low PH
    - Add acid before DAF
    - If added after tank, precipitation will occur in biological tank

    - INSERT image from Colun of Struvite builtup

THANK YOU!

Have any questions? Stay around after the presentation for a live Q&A session. Feel free to raise your hand or submit questions using the chat box.

Prefer to email us? Reach out to us at info@ssiaeration.com

Please keep an eye out for our upcoming Webinars!