Wisconsin Wastewater Operators Association
Annual Meeting, Stevens Point, WI October 23-25, 2013
Fixed Film Moving Media for Wastewater Treatment

KENNETH E. NEU, M.S.

ENVIRONMENTAL / HEALTH

PRODUCTS & SERVICE

PO Box 21 **P. O. BOX 101**

Richfield, WI 53076 **PHILLIPS, WI 54555**

Business Cell: 262-628-1300

E-MAIL: ken-ehs@juno.com

Title & Authors

When less is Truly MORE—the Next Generation of MBBR Technology--- Small Media Biofilm in a Continuous Flow Intermittent Cleaning Mode

Laura R. Marcolini[1], Ken Neu[2], Bjorn Rusten[3]

[1]Biowater Technology, LLC, 2155 Diamond Hill Rd, Cumberland, RI 02864, USA

[2]Environmental/Health Products and Service, PO Box 101 Phillips, WI 54555, USA (submitter/presenter)

[3]Aquateam, P.O. Box 6875, Rodelokka, N-0504 Oslo, Norway

Contents of Presentation

- **Brief Overview of Fixed Film Moving Media**
- **Advantages & Examples**
- **The Next Generation:**

Continuous Flow Intermittent Cleaning

Brief Overview
of
Fixed Film Moving Media

Fixed Film Moving Media Reactor Treatment

- **Developed in the 1980's primarily by Kaldnes Co. in Norway in collaboration with Trondheim University, Dr. Halvard Odegard & Dr. Bjorn Rusten.**

- **Moving Bed Biofilm Reactor (MBBR) is a general term used to describe the process. Initially MBBR was designed as a Single Pass WWT process**

Moving Bed Biofilm Reactor Technology

- Biological process—toxicity rules apply
- Requires primary treatment, FOG < 100 mg/l
- Treatment design & configuration is arranged according to inlet & outlet parameters, including WW temp.
- Organic and Hydraulic loading is variable, dependent on Infl. parameters , Eff. goals.

Fixed Film Moving Media Reactor Treatment

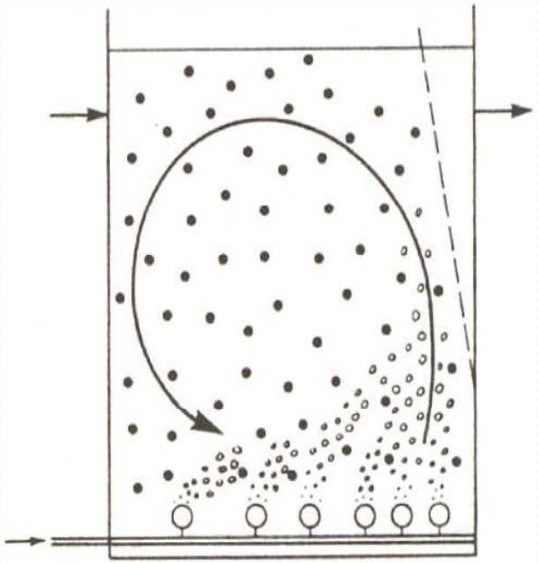
Sample of Biofilm Carriers

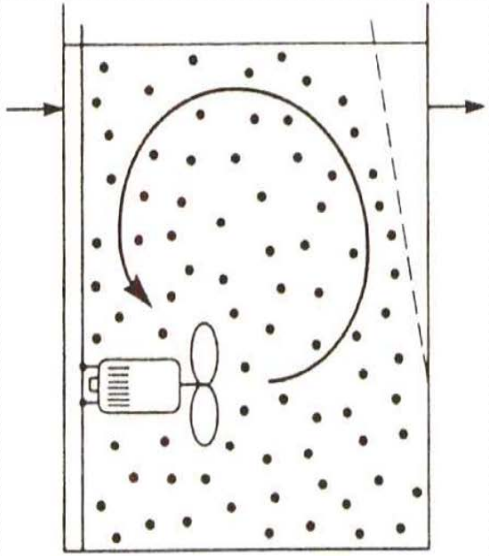
Fixed Film Moving Media Reactor Treatment

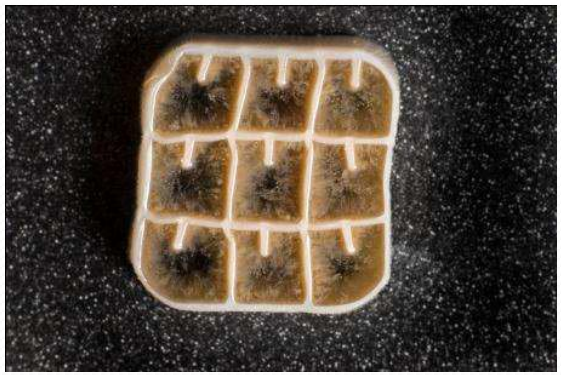
- **Carriers move throughout tank with aeration or by movement of water by mixers in an anoxic tank. No unused space in Reactor.**
- **Intimate contact of biomass w/ substrate & air**
- **Standard MBBR maximum media fill fraction**
  - **= 66 % fill of media in the reactor**
- **Media Retention Screen(s) keeps media in tank**

Fixed Film Moving Media Reactor Treatment

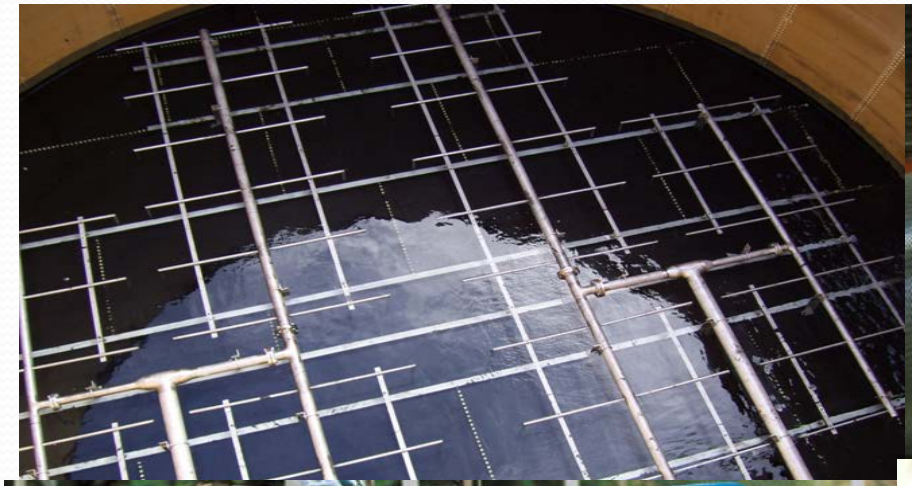
Moving Media system, Aerobic and Anoxic modes, typical Biofilm Carrier Elements.

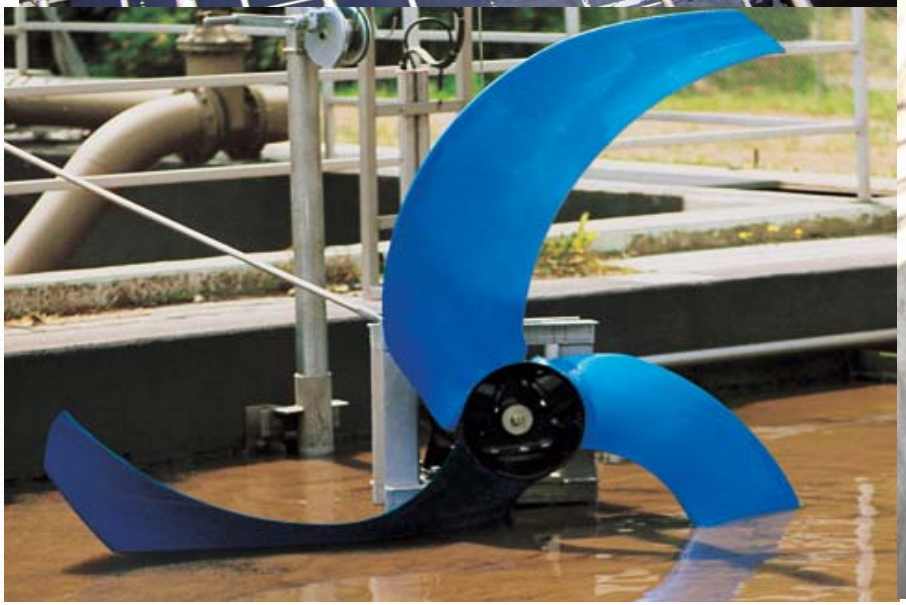






Fixed Film Moving Media Reactor Treatment





Advantages & Examples

Fixed Film Moving Media Reactor Treatment

Advantages:

- **Continuous process; Self-Cleaning Carrier Elements**
- **Operates as once-through (traditional MBBR) or multiple recirculation (IFAS, CFAS®)**
- **Cost-effective, compact design**
- **Stable & robust process: handles hydraulic and organic load variations**

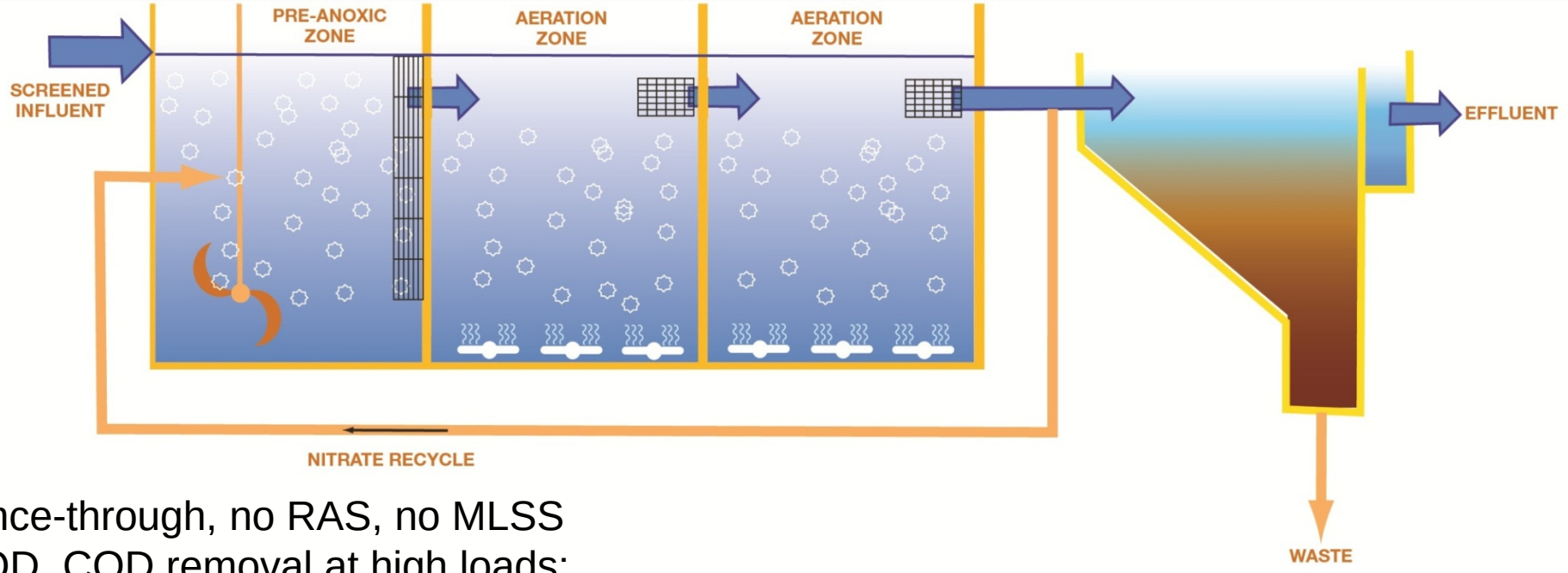
Fixed Film Moving Media Reactor Treatment

Advantages:

EASY UPGRADING OF ACTIVATED SLUDGE PLANTS TO HIGHER CAPACITIES

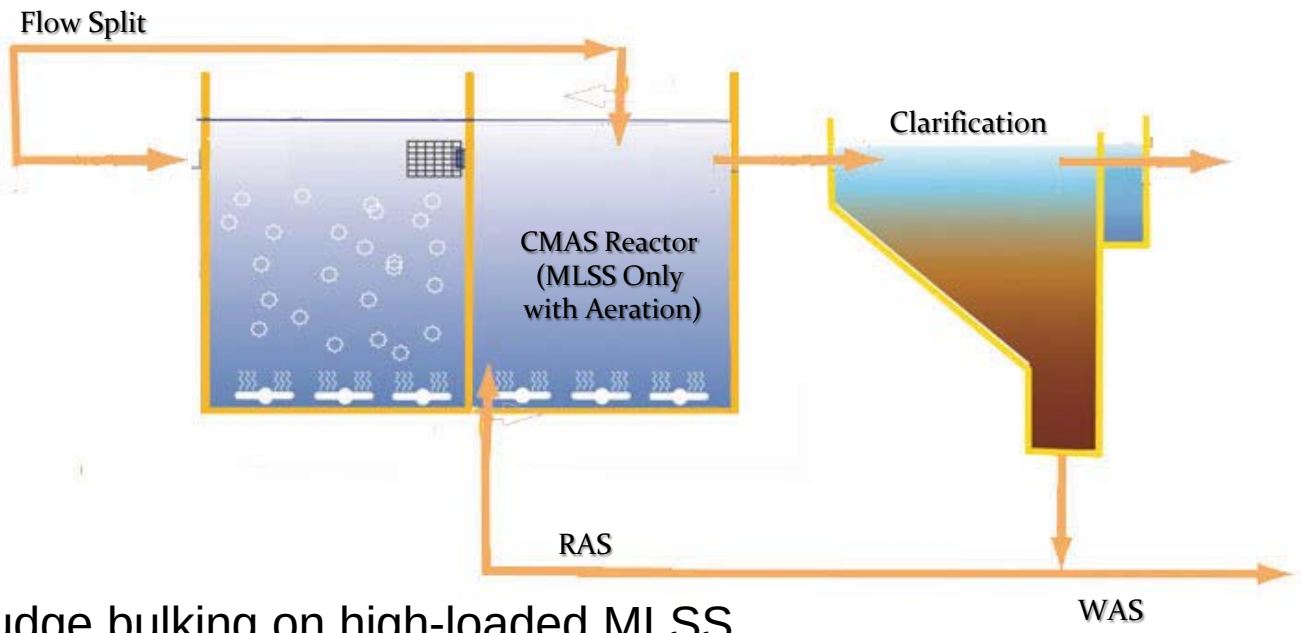
- addition within the Activated Sludge unit process to achieve IFAS / CFAS status, and
- added as a separate unit process- within Flow Path, upstream or downstream of existing Fixed Film, AS or Lagoon.

Complete Mix Fixed Film (CMFF®)



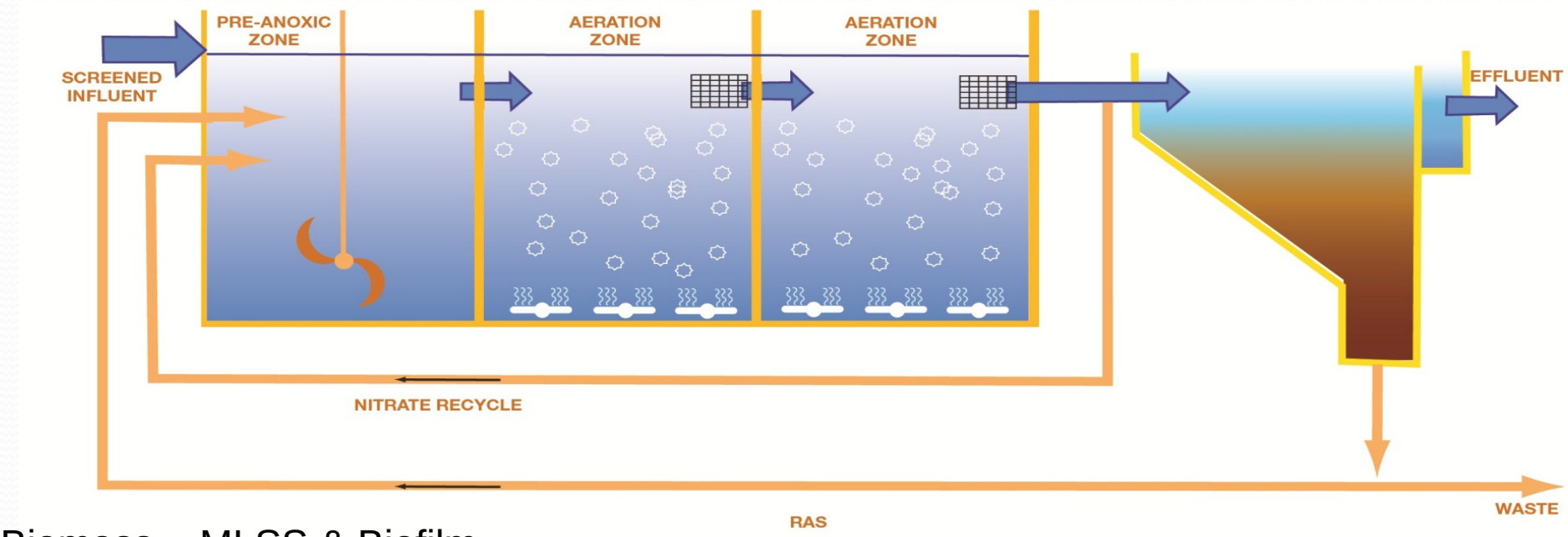
- Once-through, no RAS, no MLSS
- BOD, COD removal at high loads:
  - * Municipal >17Kg/m^3-day
  - * Industrial <= 17Kg/m ft^3-day
- Nitrogen removal with low HRT: < 3 mg/L with 6 hr HRT
- Small footprint
- Operator friendly
- CSTR conditions, homogeneous bed, continuous solids sloughing

CMFF® - Activated Sludge



- Eliminates sludge bulking on high-loaded MLSS
  - (SVI reductions >300 down to < 100)
- Stabilizes organic removal:
  - Installations with 10x load fluctuations
  - CMFF® process providing 80-90% organic removal
- Small footprint (0.5 hour HRT or greater)
- Low Implementation Cost

Combined Fixed Film and Activated Sludge (CFAS®)



- Biomass = MLSS & Biofilm
- Compartmentalize BOD Removal, Nitrification, and Nitrogen Removal
- Biological P removal with anaerobic selector
- Carriers/Biofilm optimizes nitrification, limiting kinetic rate in BNR
- Selective pollutant degradation by carriers/biofilm: organic compounds, post DN

Small Media Aerobic Reactor Treatment
(SMART On-site wastewater Treatment Systems)

- ✓ **EHS has DOWN-SIZED this technology to <u>Very Economical</u> *Decentralized* SMALL FLOW and ON-SITE wastewater treatment applications**

- ✓ **Wisconsin approval has been accomplished for the Small Flow (<1333 P.E.) ON-SITE AEROBIC TREATMENT SYSTEM, with several EHS-SMART-Treatment On-site systems installed since 2001**

Small Media Aerobic Reactor Treatment
(SMART-Treatment On-site Systems)

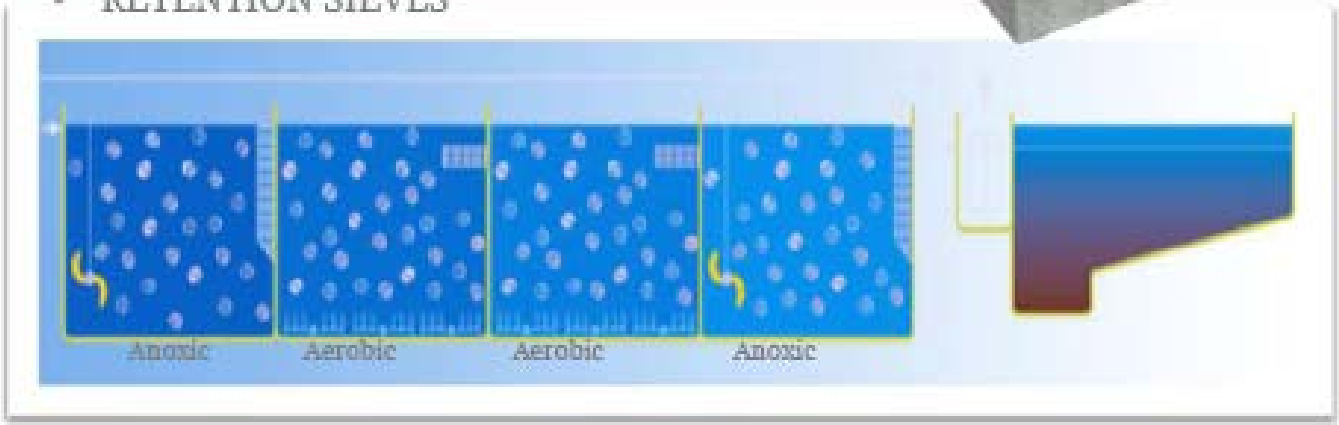
EHS SMART System Small Flow Sizing, BOD + Nitrogen Rem

Pop Equiv	WW Q gpd STE	Inf BOD Lbs / day	Reactor gallons	HRT-av Q, hrs	Media, % fill	Tank Depth
5	**400**	**0.77**	**530**	**31**	**10**	**3.5**
50	**4,000**	**7.7**	**5300**	**5**	**64**	**4**
500	**40,000**	**77**	**8350**	**5**	**64**	**6**
1000	**80,000**	**154**	**16,500**	**5**	**64**	**10**

Small Media Aerobic Reactor Treatment
On-site package plants: cluster developments, etc.

PROCESS COMPONENTS

- **AEROBIC**
  - BIOFILM CARRIERS
  - AERATION SYSTEM
  - RETENTION SIEVES
- **ANOXIC**
  - BIOFILM CARRIERS
  - MECHANICAL MIXERS
  - RETENTION SIEVES



Small Media Aerobic Reactor Treatment SMART On-site treatment tank

Water Environment Federation's (1998) MOP 8, "Design of Municipal Wastewater Treatment Plants" **Surface Area of Stationary Media Bundles**

Typical Wastewater Strength Categories	Surface Area , Sq Ft / Cu Ft Stationary Media Volume
High Strength Waste:	**30.5 sq ft/cu ft**
Domestic, BOD removal:	**36 sq ft/ cu ft**
Nitrification applications:	**42 sq ft/ cu ft**
RBC: – std den / high den	**34 sq ft & 56 sq ft / cu ft**
Moving Media Comparison, at 66 % Fill Fraction	
BWT-X@198 sq ft/cu ft-bulk	**131 sq ft / cu ft- In Reactor**
BWT-15@ 253 sq ft/cu ft-bulk	**167 sq ft/cu ft- In Reactor**

Water Environment Federation's (1998) MOP 8, "Design of Municipal Wastewater Treatment Plants"

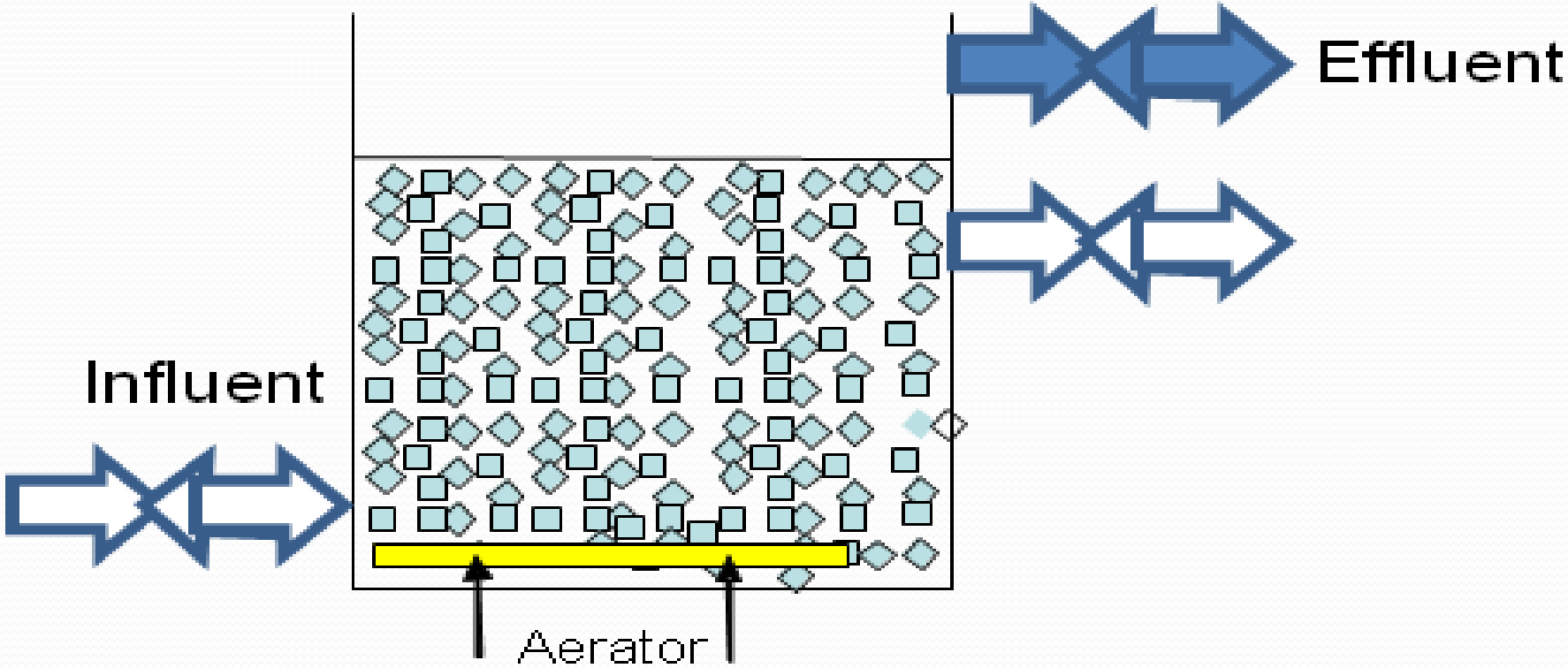
Typical Wastewater Strength Categories	Surface Area , Sq Ft / Cu Ft Stationary Media Volume
High Strength Waste:	**30.5 sq ft/cu ft**
Domestic, BOD removal:	**36 sq ft/ cu ft**
Nitrification applications:	**42 sq ft/ cu ft**
RBC: – std den / high den	**34 sq ft & 56 sq ft / cu ft**
Moving Media Comparison, at 66 % Fill Fraction	
BWT-X@198 sq ft/cu ft-bulk	**131 sq ft / cu ft- In Reactor**
BWT-15@ 253 sq ft/cu ft-bulk	**167 sq ft/cu ft- In Reactor**
CFIC—BWT-X @ 99% Fill	**196 sq ft / cu ft- In Reactor**
CFIC—BWT 15 @ 99% Fill	**250 sq ft /cu ft- In Reactor**

The Next Generation: Continuous Flow Intermittent Cleaning

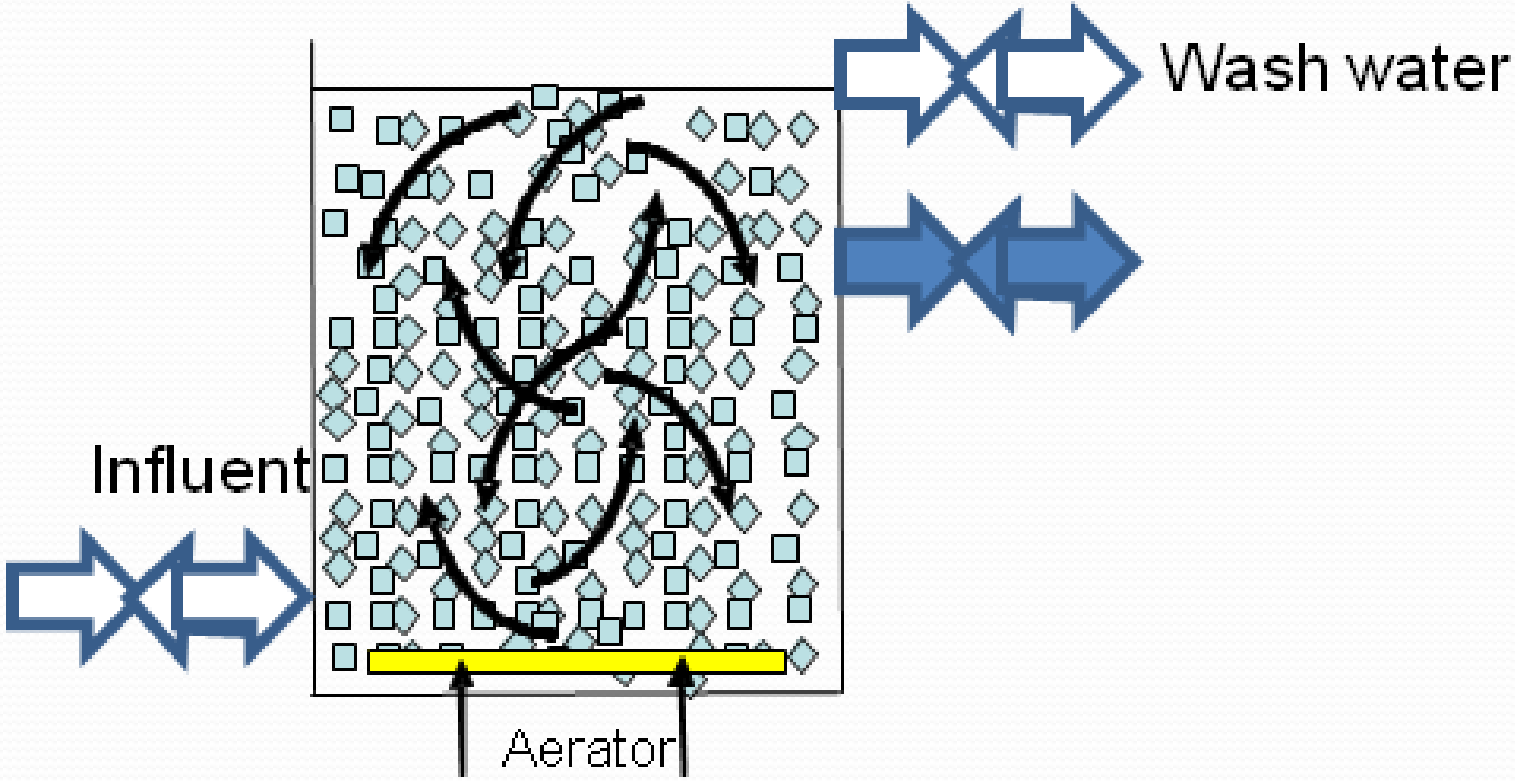
Doing More with Less—Biowater's Newest Innovation- Better Treatment In An Even Smaller Foot Print: **Continuous Flow Intermittent Cleaning**

- The CFIC® reactor contains highly packed biofilm carriers to a degree (typically 90-99% bulk volumetric fill) that little movement of the carriers occurs in the reactor during normal operation.
- For example using Biowater BWT-X carrier elements---
  - By increasing bulk volumetric fill from 66 % maximum fill to 99% maximum fill, the reactor biological surface area **INCREASES** from 131 sq ft/cu ft to 196 sq ft/cu ft w/in **same reactor volume— A 50 % INCREASE IN SURFACE AREA!**

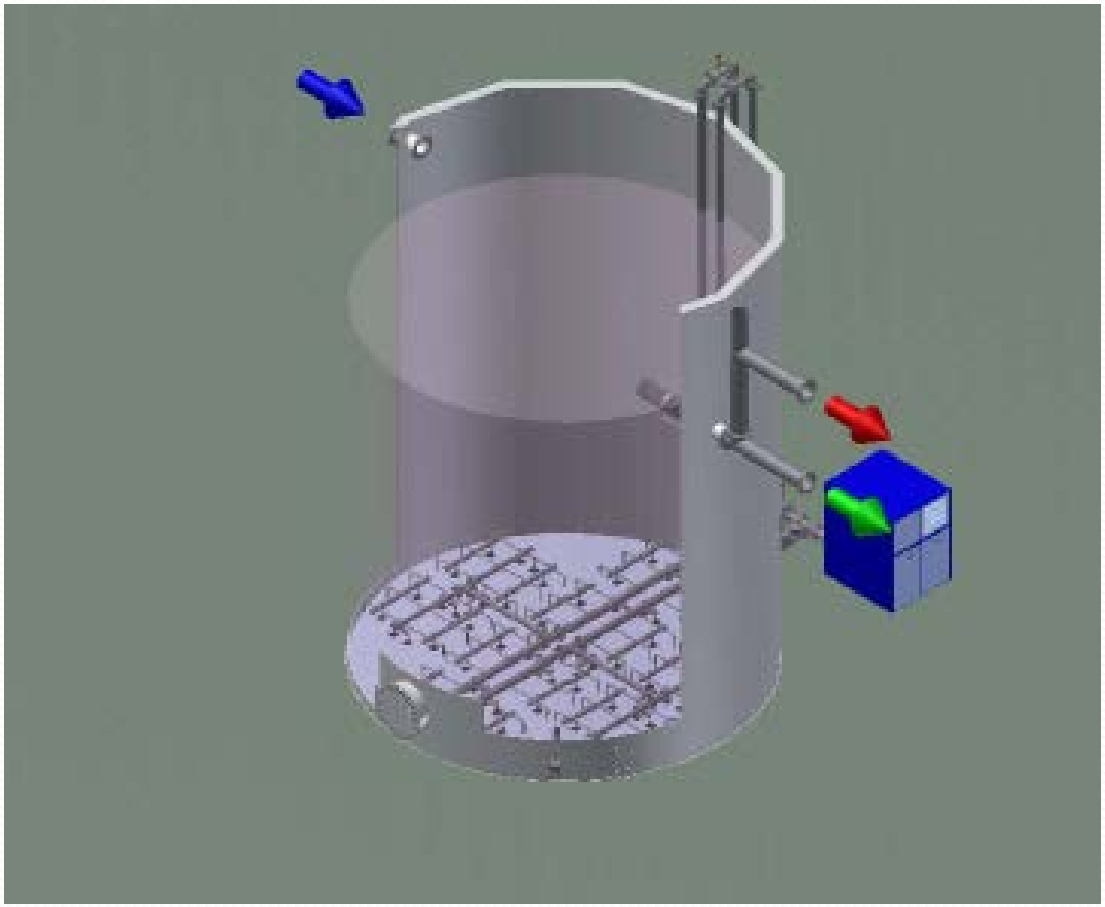
CFIC®—Normal Operation



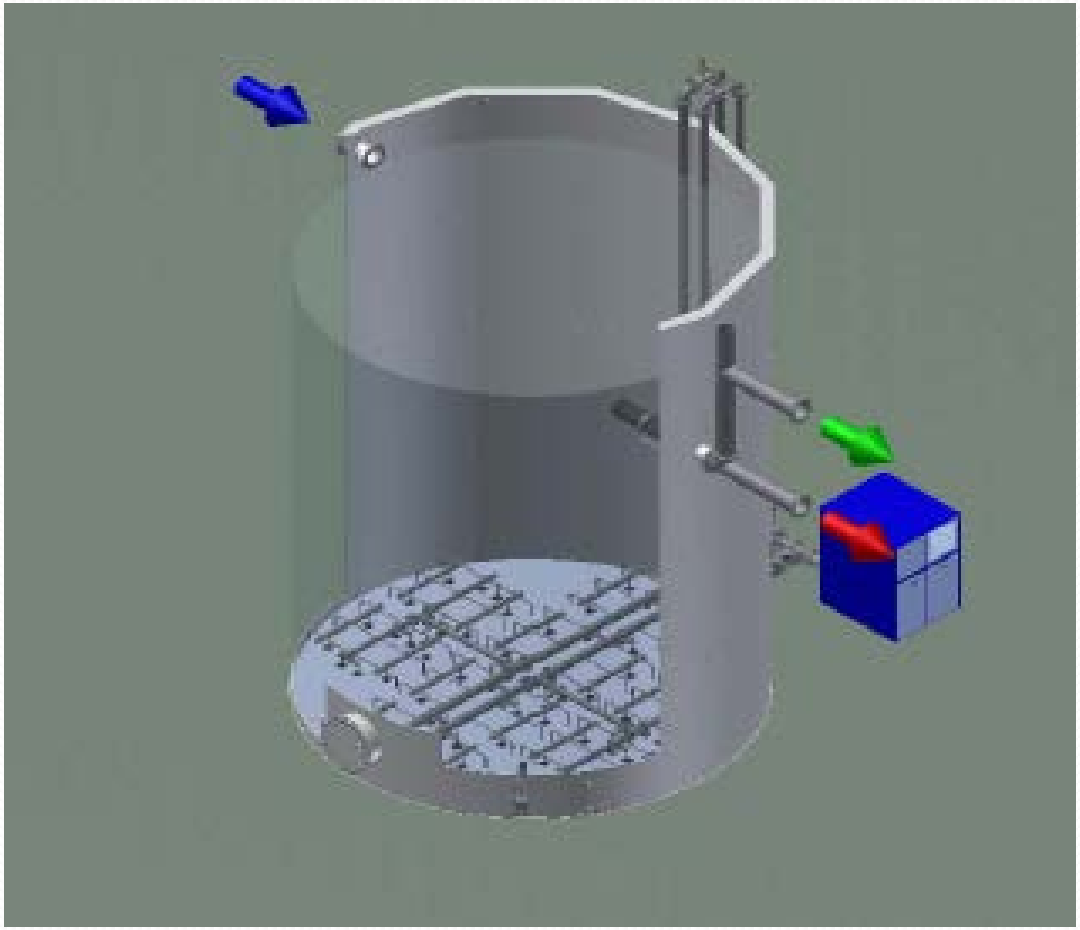
CFIC®—Intermittent Cleaning



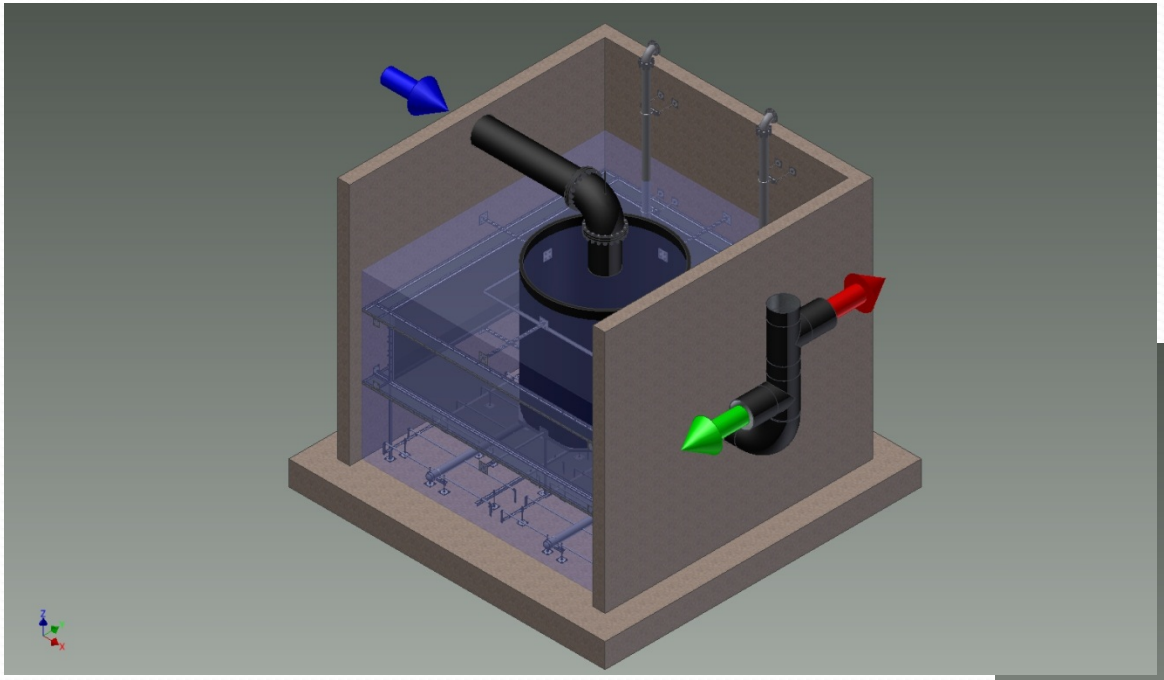
CFIC Reactor---CFIC Elevation

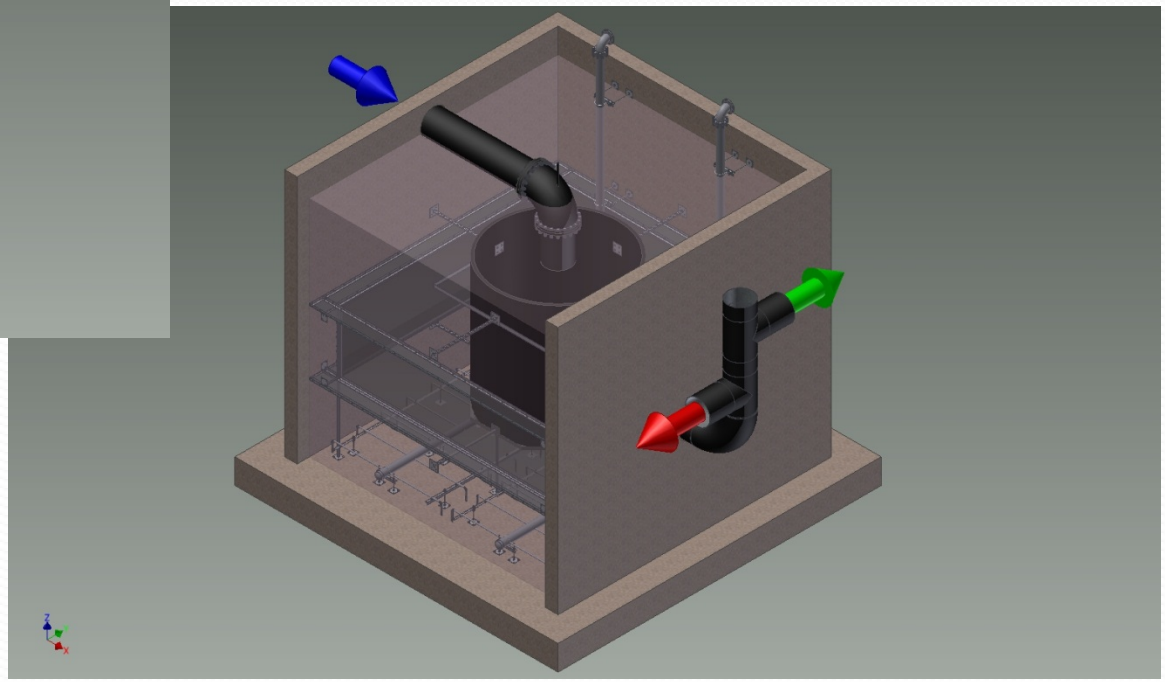


CFIC Reactor---Clean Cycle



Typical CFIC Reactor





Biowater Technology's CFIC® process

- The cleaning cycle is a forward wash cycle (FWC) in that influent wastewater continues to flow into the CFIC® reactor. The cleaning process removes biomass (biofilm and excess sludge) from the biofilm carriers and out of the reactor.
- The turbulence in the reactor may temporarily be increased with an air-lift pump or a propeller to facilitate effective removal of biomass from the carriers
- The carrier shape provides a large void volume (typically an 85% void volume in a 100% fill situation) for growth and accumulation of biomass. The void volume maximizes the run time between cleaning cycles.
- Wastewater treatment with a:

BIOLOGICAL TURBO– More Treatment in Less Space

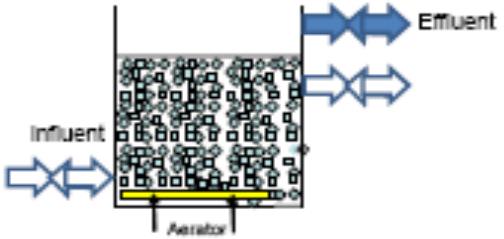
Biowater Technology's CFIC® process

CFIC® – The next generation biofilm technology

BIOWATER TECHNOLOGY

CFIC® biofilm technology is based on biological growth on polyethylene pieces. CFIC® provides a protective surface area for the biology to grow and can easily handle extremely high loads of wastewater without problems with clogging or shock.

Normal operation



- Bioreactor is filled >90% with biofilm carriers
- Hindered carrier movement
- Higher O_2 Transfer
- Better transportation of substrate

Open valve:
Closed valve:

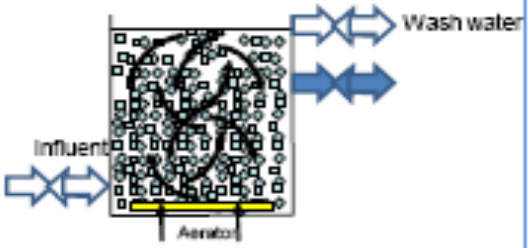
Biomedia

before...

...and after

cleaning cycle

Intermittent cleaning



- Water level in the bioreactor is increased to let the carriers move
- Accumulated sludge and adhesive biofilm are being removed from the carriers and washed out of the reactor
- The bioreactor is fed by untreated wastewater during washing and is still performing treatment during wash cycle

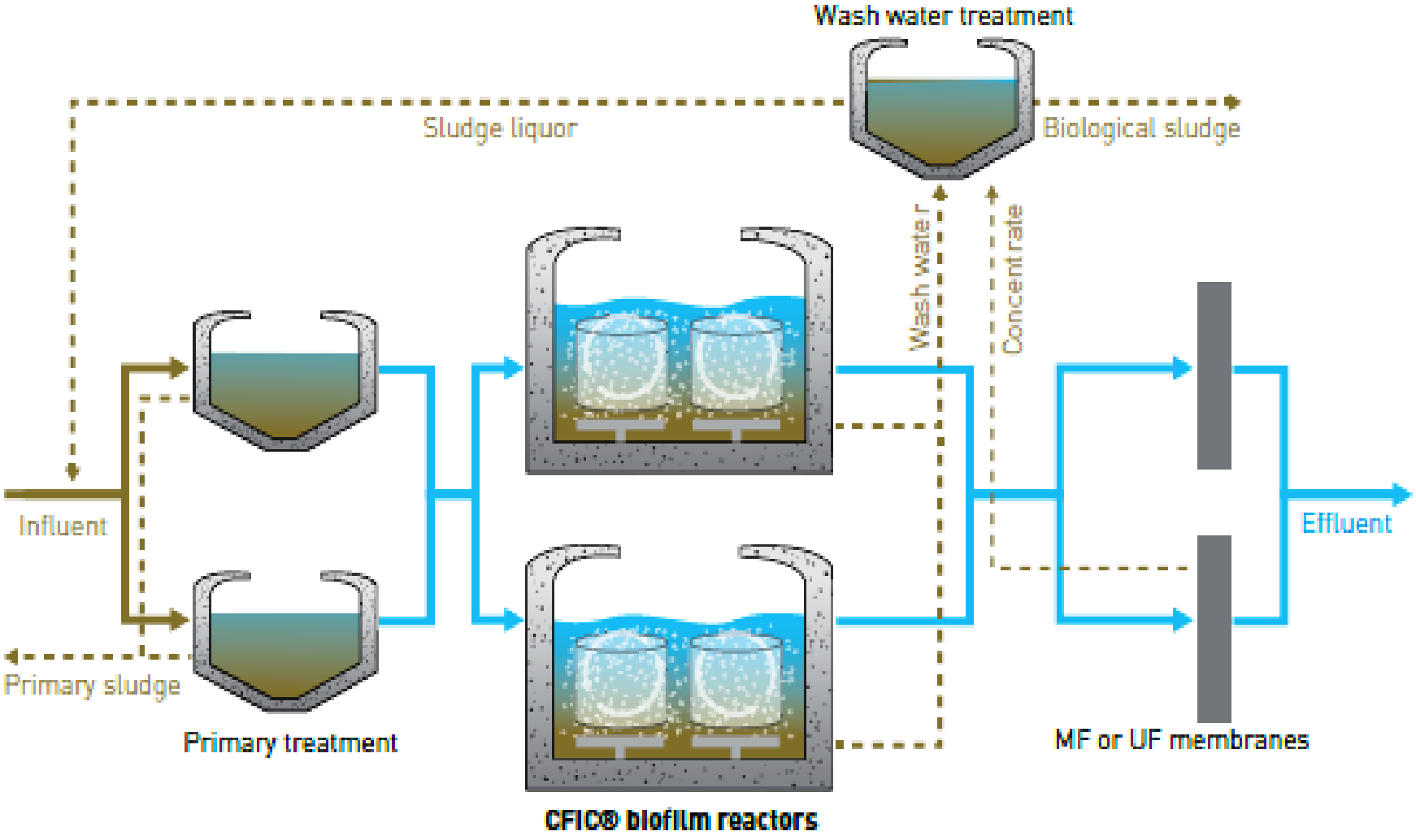
Wastewater treatment with a biological turbo

CFIC® Biofilm Process

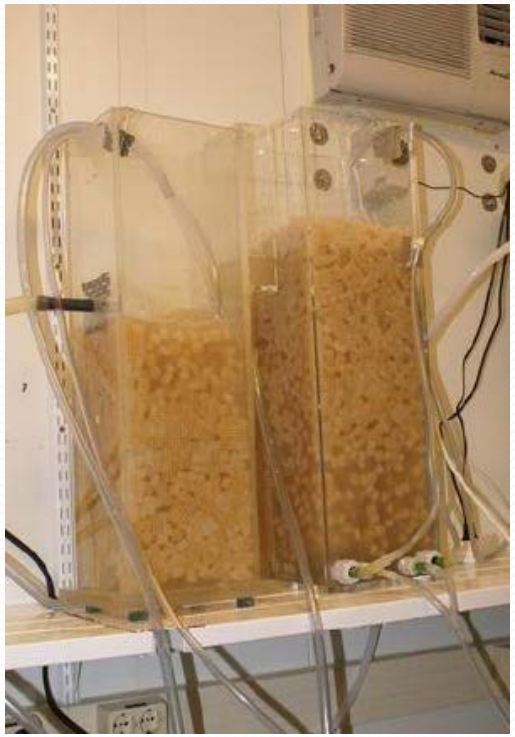
Controlled Wasting of Solids

- High Volatile Solids Content / Renewable Energy Component
- Solids directly to Thickening/Dewatering
- Low Effluent TSS Concentration, 50 – 90% Less Than MBBR
- Filtration for Effluent Reuse
- Continuous Biological Treatment
- Water is dischargeable depending on effluent requirements
- Water does not need to be recirculated
- No Polymer Dosing
- Energy Savings of 20-30%

CFIC®-Parallel Trains, w/ direct flow from CFIC Reactors to micro-filtration or Ultra-fine Membranes



CFIC® Pilot Development

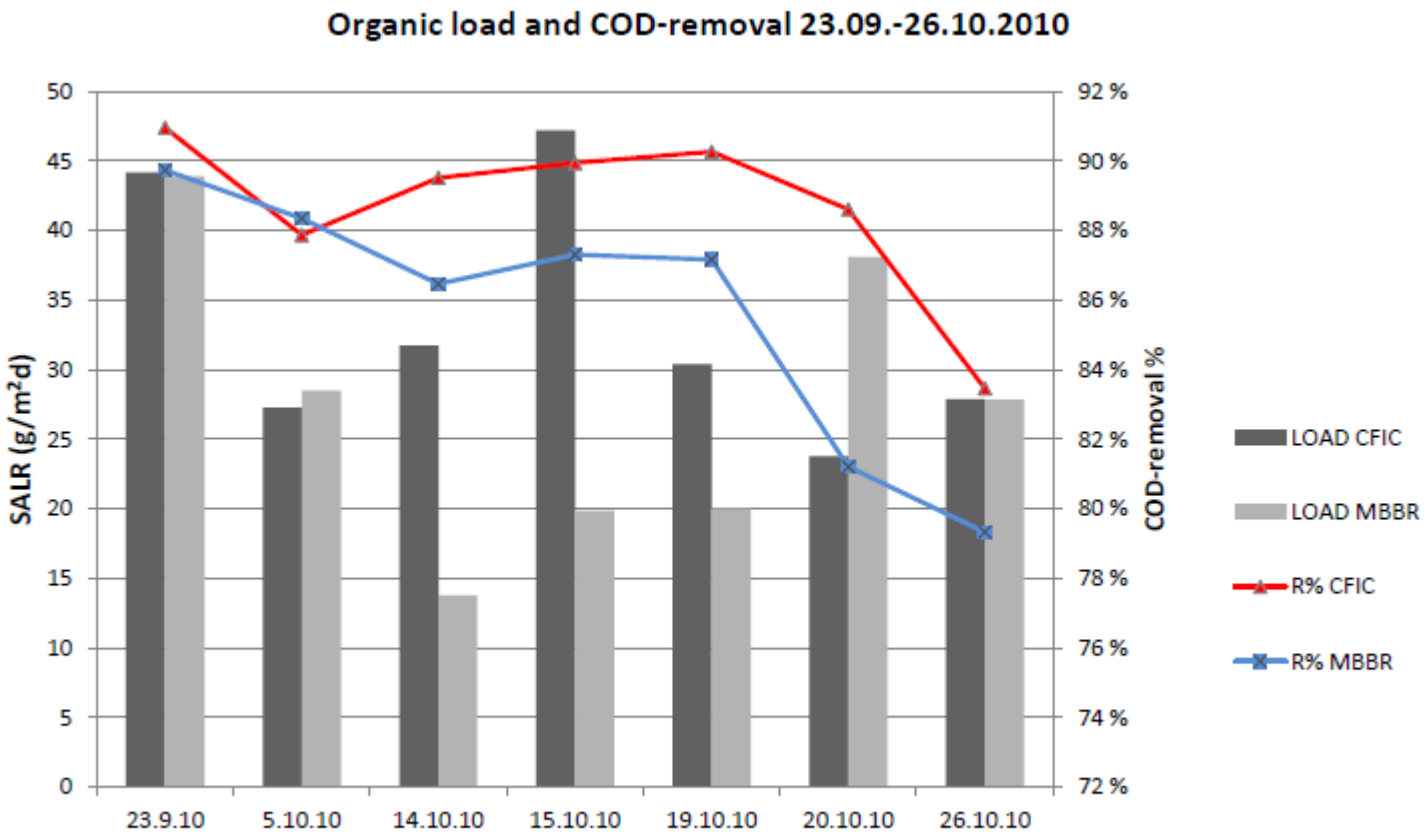


CFIC®--Pilot Data

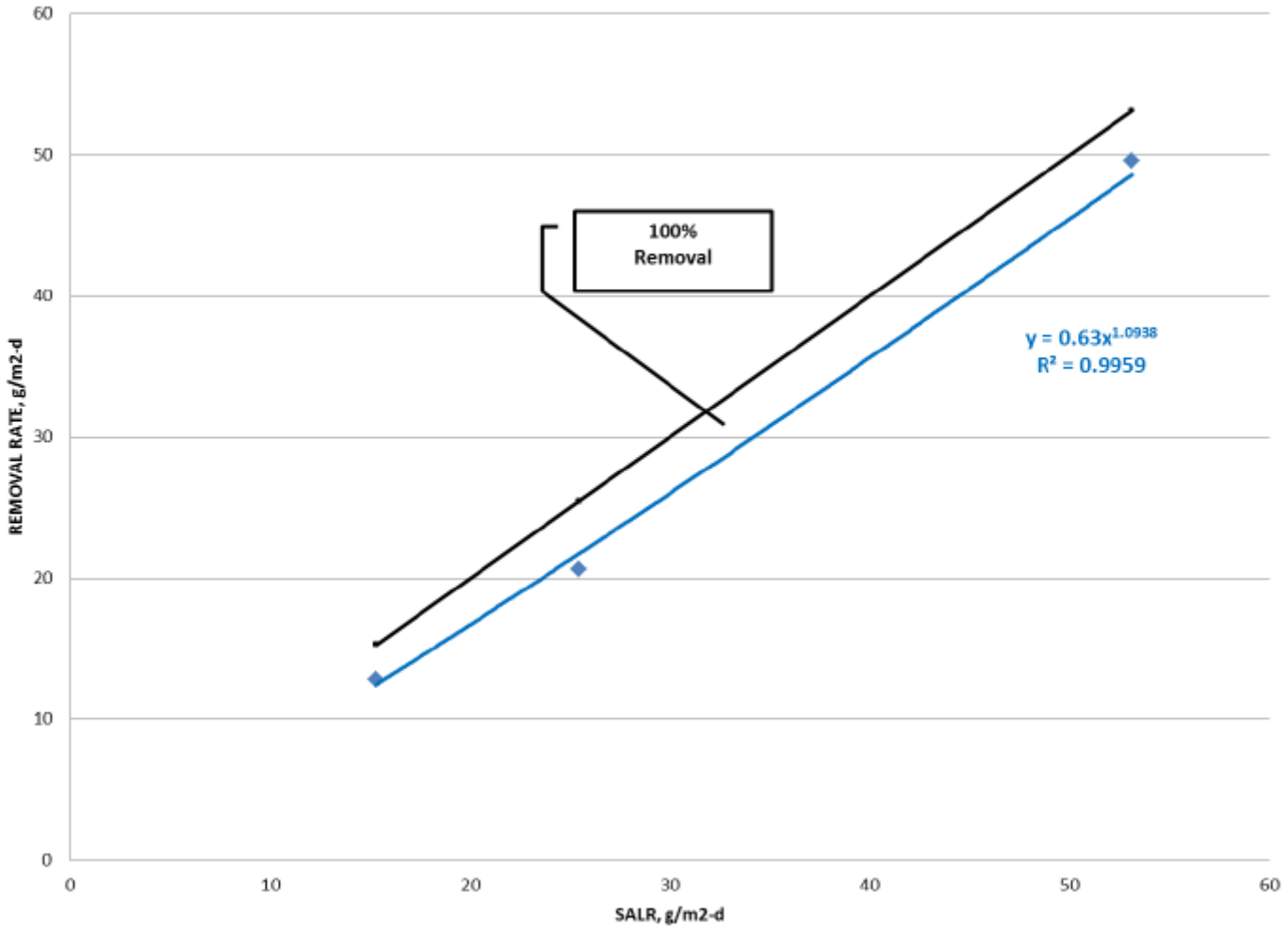
- Reactor diameter Ø = 2,5m
- Reactor height H = 6,0 m
- Water level: CFIC = 4,0 meter FWC = 5,0 meter
- Filling degree: CFIC = 95 % FWC = 76 %
- Water volume: CFIC = 12,6 m^3 FWC = 15,7 m^3

- Hydraulic load Q = 2,0 – 5,0 m^3/h
- COD 2500 – 8000 mg/l ~ 300 - 850kg COD/d
- COD Removal rate R > 90 %
- Wastewater temp. T = 30 – 34 °C

CFIC vs. CMFF (conventional MBBR)



COD RR vs. SALR



Sampling & Analytical

BIOWATER TECHNOLOGY

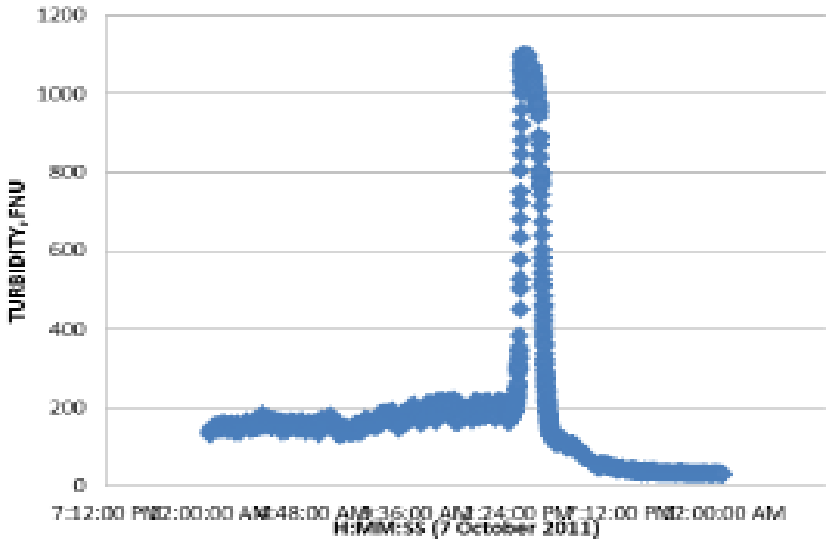
- Online Monitoring:
  - Turbidity
  - DO
  - ORP
  - Temperature
  - Nitrate, Ammonia
  - Blower Amps

- Analytical (24-hr Composites and Grabs):
  - TCOD, sCOD, TSS, VSS, Turbidity
  - Correlation of TSS to Turbidity

Online Turbidity

BIOWATER TECHNOLOGY

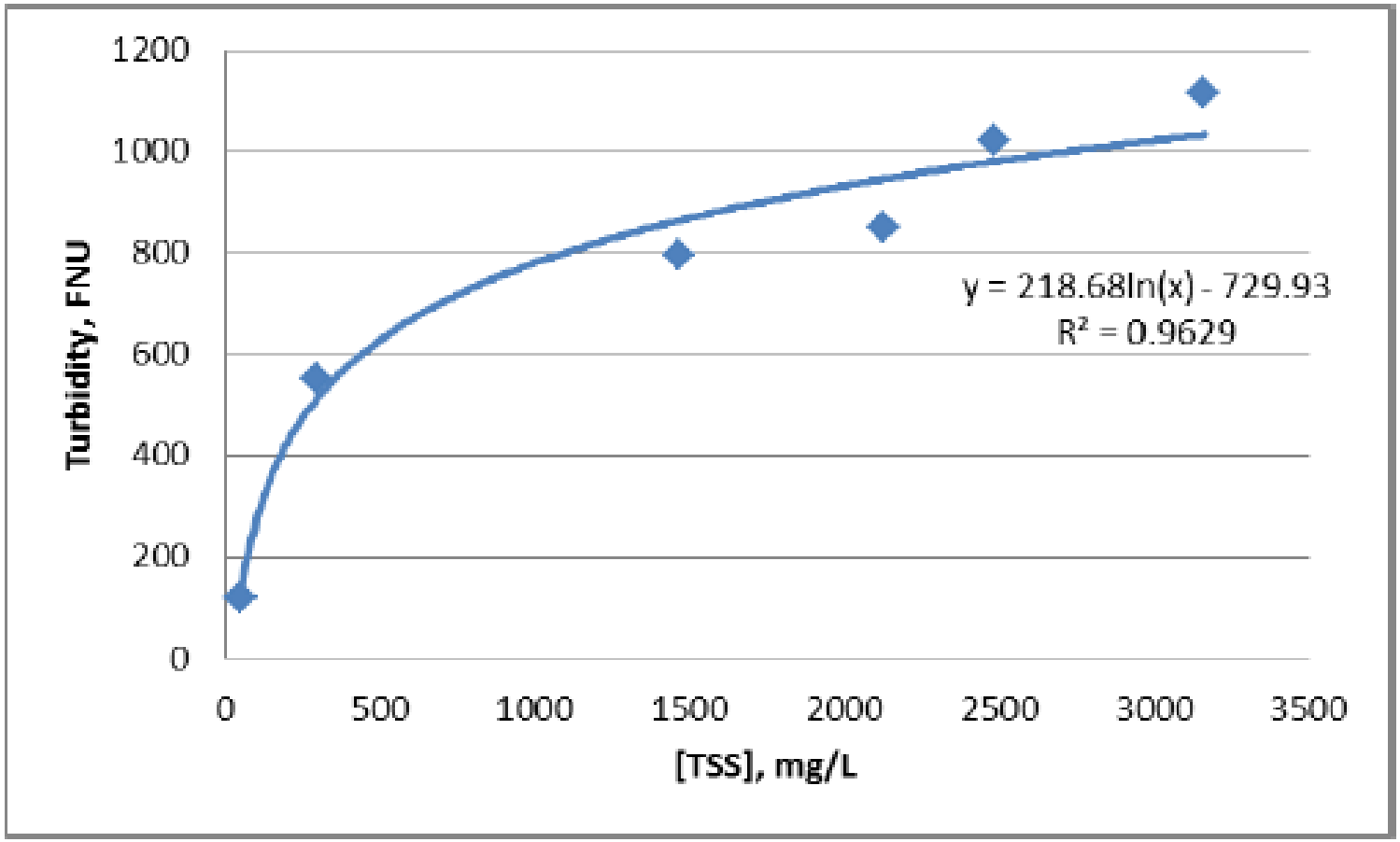
Online Turbidity Monitoring allows calibration to [TSS] and Process Control



200 FNU
50-60 mg/L TSS

Wastewater treatment with a biological turbo

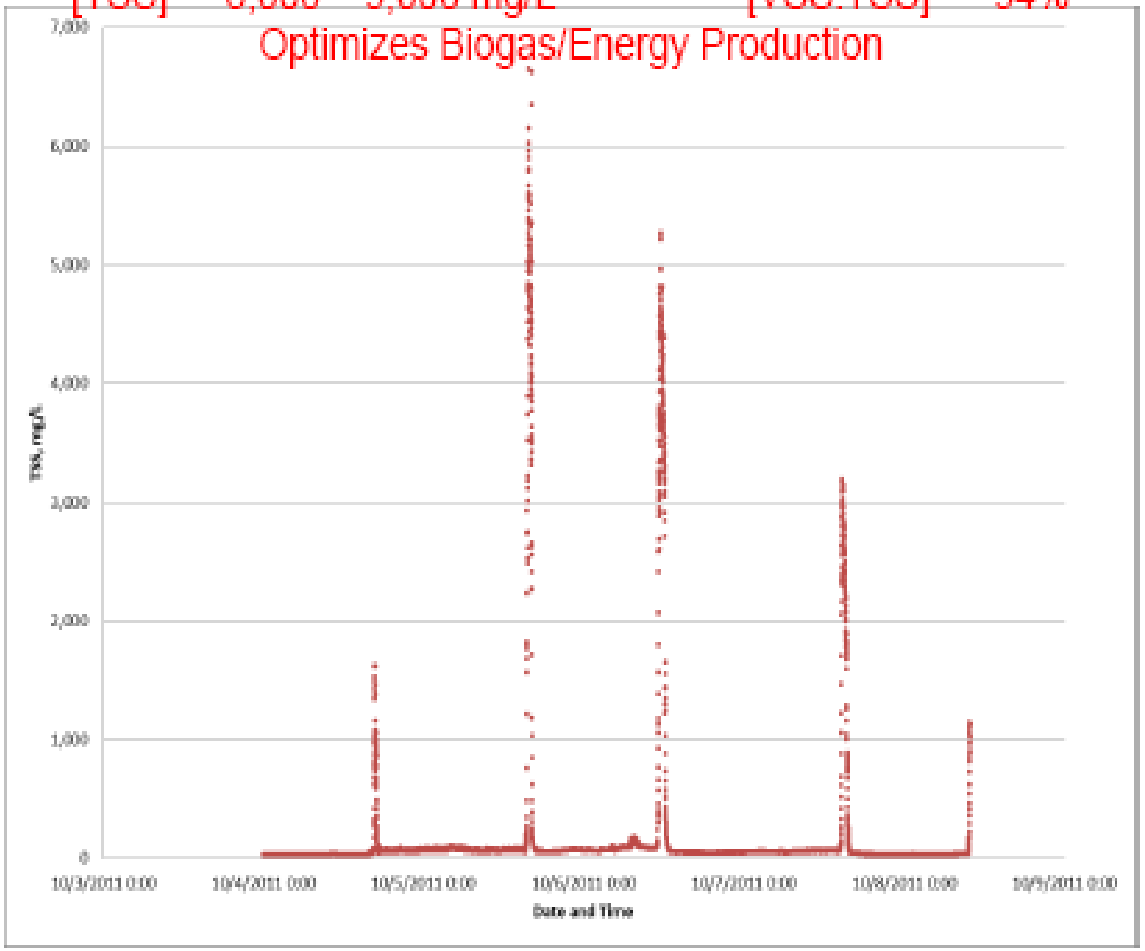
Turbidity to [TSS]



Wasting Cycle TSS

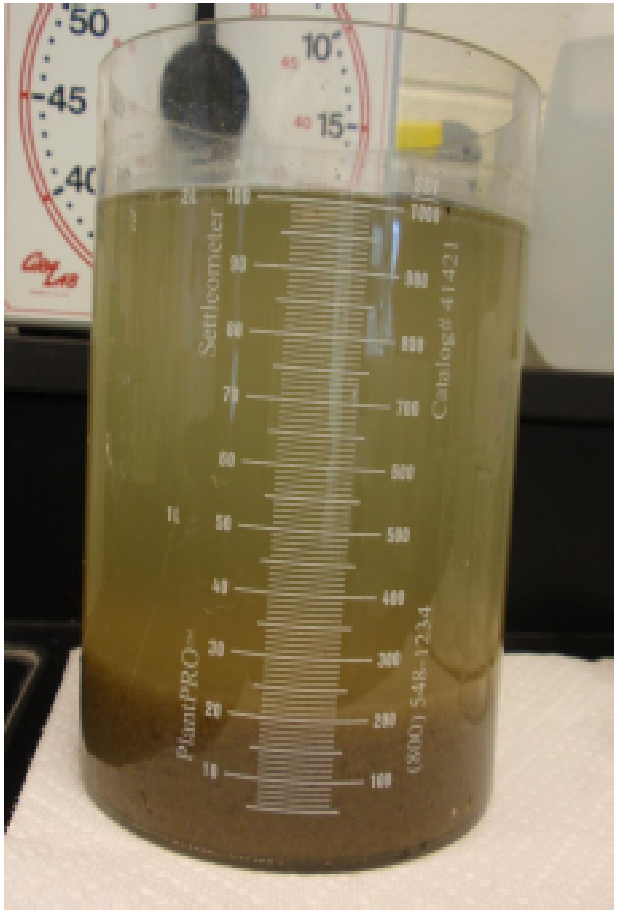
[TSS] 3,000 – 9,000 mg/L [VSS:TSS] 94%

Optimizes Biogas/Energy Production



Wastewater treatment with a biological turbo

Sludge Volume Index (Waste)



15 October 2011

Sludge Volume 220 mL per 1000 mL

[TSS] = 4,690 mg/L (Waste)

SVI = 47 mL/g

Peak Day
920 mg/L COD

170 mL Sludge Volume

9,000 mg/L TSS (Waste)

SVI = < 20 mL/g

---Summary—
Biowater Technologies CFIC® process

- CFIC® Biofilm process- a new development in MBBR technology
- The CFIC® reactor is filled to a high degree of biofilm carriers (typically 90-95% fill fraction)
- The high filling will create a hindered movement of the carriers in the reactor during normal operation
- The CFIC® process has continuous flow to the bioreactor and intermittent cleaning

-- GLOBAL PRESENCE –

Biowater Technology & Licensees

BIOWATER TECHNOLOGY

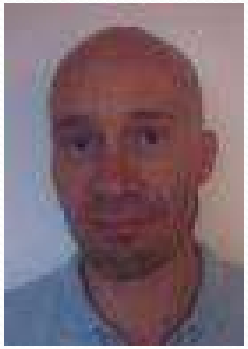
GLOBAL PRESENCE

Today's Biowater Technology & Licensees

BIOWATER'S EXPERIENCED TEAM

Laura Marcolini, P.E., M.Sc. - Technical Director, US

- Process Design Engineer for Kaldnes / Regional Manager for AnoxKaldnes.
- ~ 20 years' water and wastewater process experience



- **Jon Gregar Siljudalen, M.Sc. – Chief Technical Officer**
- • Senior Process Engineer Kaldnes Miljøteknologi - AnoxKaldnes
- • Formerly with the municipality of Oslo and Hjellnes COWI

BIOWATER'S EXPERIENCED TEAM

Thorbjørn Westrum, M.Sc. (Founder & Board Member)

- Founder of Kaldnes Miljøteknologi AS and Managing Director from 1990 to 1999.
- Managing Director of Kaldnes, one of the largest shipyards in Norway.

Terje Andersen (Founder & CEO)

- Managing Director of Kaldnes Miljøteknologi 1999 - AnoxKaldnes until June 2007.
- ~25 years International Sales and Marketing.

EHS & Biowater - A Good Team

Summary—Fixed Film Moving Media Treatment:

- ✓ Teamed with engineers & companies w/ the most experience & innovative products/processes in fixed film moving media treatment of Water & Wastewater
- ✓ Can supply process knowledge and product for ANY volume or process configuration
- ✓ Provides maintenance agreements where/when needed
- ✓ Strive for BEST Treatment @ Lowest Price, both initial investment and O & M.

Environmental /Health Products & Service

Thank You for the opportunity!