The Metropolitan

Water Reclamation District

of Greater Chicago

WELCOME TO THE DECEMBER EDITION OF THE 2017 M&R SEMINAR SERIES

BEFORE WE BEGIN

- SAFETY PRECAUTIONS
 - PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVACUATION
 - AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE
- PLEASE SILENCE CELL PHONES OR SMART PHONES
- QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION
- PLEASE FILL EVALUATION FORM
- SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www. MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2017 Seminar Series)
- STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)

Louis V. Storino, P.E., BCEE

Current: Principal Civil Engineer, Engineering Department, MWRD

Experience: Being in the Engineering Department, Collection Facilities/ Tunnel and Reservoir Plan (TARP) Section, Mr. Storino supervises a staff of five engineers, conducts engineering studies and analysis. He has been with MWRD since 1998 and has held numerous positions in both the Maintenance and Operations Department (M&O) and the Engineering Department.

Education: B.S. in Chemical Engineering and M.S. in Environmental Engineering, both from the Illinois Institute of Technology, Chicago, Illinois MBA in Finance from DePaul University, Chicago, Illinois

Professional: Registered Professional Engineer in Illinois Board Certified Environmental Engineer by AAEES Member of the Water Environment Federation (WEF) Treasurer of the Illinois Water Environment Association (IWEA)

Katarzyna (Kathy) Lai, P.E.

Current: Principal Engineer, Operations Manager, John E. Egan WRP, M&O, MWRD

Experience: - Operations Manager at the Egan WRP, managing both waste water treatment and solids operations including biosolids processing and sidestream treatment (ANITA[™] Mox).

- Senior Mechanical Engineer North Side WRP (now O'Brien WRP). Responsible for managing the mechanical maintenance of equipment within the plant and at the outlying locations.

- Associate Mechanical Engineer, at Calumet WRP. Responsible for mechanical maintenance of the plant equipment within the areas of responsibility.

Education: B.S. in Chemical Engineering, University of Illinois at Chicago, Illinois

Professional:Water Environment Federation (WEF)Illinois Water Environment Association (IWEA)

Dongqi (Cindy) Qin, Ph.D.

Current:Environmental Research Scientist, Wastewater Treatment ProcessResearch Section, M&R, MWRD

Experience: Wastewater treatment process research and development (2 WEF conference proceedings)

- Sidestream deammonification for nitrogen removal

- Enhanced biological phosphorus removal pilot and full-scale tests Applied chemistry (24 peer reviewed journal papers; citations 1,820 times)

- Formulation of new biomedical materials
- Organic/environmental samples analyses with various instruments

Education: Ph.D. (Chemistry), Beijing University, China
 M.S. (Chemistry), Jilin University, China
 B.S. (Polymer Chemistry and Physics), Jilin University, China

Professional: Water Environment Federation (WEF) American Chemical Society (ACS)



Metropolitan Water Reclamation District of Greater Chicago

ANITATM Mox Startup and Optimization at the Egan Water Reclamation Plant



Presented By

Kathy Lai, PE Cindy Qin, PhD Louis Storino, PE Principal Civil Engineer, Principal Engineer, M&O **Environmental Research** Scientist, M&R Engineering III MILLANDARDARDARDARD Can Mari



Acknowledgements

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- Glenn Thesing

Operators and Plant Staff

- Hitesh Shah (Plant Manager)
- John Kargbo
- Kent Anderson
- Adam Johnson
- April Browing
- John Alkovich
- Keith Myrda
- Kenneth Massey
- Dev Rijal

- Jeffery Simpson
- Kenneth Gavin
- Maurice Smith
- Vit Riew
- Mary Brand *
- Many more!

*Retired



Outlines

- Egan WRP
- NPDES Ammonia Limits
- Deammonification Process
- AnitaTM Mox Design Summary
- Process Overview
- Startup
 - Operation
 - Monitoring and Process Control
 - System Improvements
 - Data and FISH (Fluorescence In Situ Hybridization)
- Lessons Learned
- Conclusions





John E. Egan WRP

- Service Area: 44.4 square miles
- Service Population: 160,735
- •Type: Single Stage Nitrification with Tertiary Filtration and Disinfection
- Design Average Flow: 30 MGD 2016 Average Flow: 24.2 MGD
- Design Maximum Flow: 50 MGD Storm Flow Total: 140 MGD
- Receiving Stream: Salt Creek





NPDES Limits Ammonia-Nitrogen

	Load	d Limits – lb DAF (DMF)*	os/day	Con	centration mg/L	Limits	Sample Frequency
	Monthly Average	Weekly Average	Daily Maximum	Monthly Average	Weekly Average	Daily Maximum	Composite Sample
April-Oct.	375 (626)		751 (1 , 251)	1.5		3.0	2 days/week
NovFeb.	901 (1,501)		2,002 (3,336)	3.6		8.0	2 days/week
March	575 (959)	1426 (2377)	2,002 (3,336)	2.3	5.7	8.0	2 days/week

* Load limits based on design maximum flow shall apply only when flow exceeds design average flow



Partial Nitritation-Deammonification





Moving Bed Biofilm Reactor





Challenges

- Slow growth rate of anammox bacteria
- Exceeding mainstream capacity
- Alkalinity or micronutrient limitation
- Centrate availability
- Inhibiting NOB
- Temperature





- Prior operation at Egan required centrate to be pumped from the Egan WRP to the O'Brien WRP for treatment. Centrate had up to \sim 45% of plant N load.
- The ANITATM Mox project it reduces the ammonia load (~by 75%) in the return of the plant's centrate to the secondary treatment process will possibly allow the Egan mainstream secondary process to treat the ANITATM Mox effluent and residual untreated centrate at the facility.
- Project plans to eliminate the pumping of centrate from the Egan WRP to the O'Brien WRP, a distance of ~17 miles.
- The installation was using the existing infrastructure:
 - Retrofit thickener tanks
 - Aeration demand provided by the plant's existing blower capacity







ANITATM Mox Design Summary









pH, DO, NH3/NO3

ANITA Mox Reactors

Credit to Kruger for slide





TO HEADWORKS

Credit to Kruger for slide

ANITATM Mox Centrate Treatment (construction photo) at the Egan WRP.

10

Closer look at the reactor interior, mixers, air grid and effluent screen

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-Conterna

2.3

J #1



- Typical startup estimated to take approximately 14 weeks
- Seeded media installed in two separate events a week apart
 - August 17, 2016 and August 24, 2016
 - Egan system used 10% seeded media, remainder 90% new media
 - 50 cubic meter bags of seeded media
 - 450 cubic meter bags of new media



Pre-startup: New media conditioning Startup process:

- 1. Batch
- 2. Intermittent
- 3. Continuous at low flow rates (80 gpm) and increasing
- 4. Continuous at design rates



Loading Seeded Media Into Reactors



Loading Seeded Media Into Reactors









Three stages of startup

- Initial Startup
 - August 26, 2016 December 22, 2016
 - Achieved 120 gpm for 7 days
 - Average flow 44 gpm
- Standby Period
 - December 23, 2016 August 2017
 - System placed in idle 29 days (10 day max cont)
 - Maintained low flow (avg 13 gpm)
- Secondary Startup
 - August 2017 Present
 - Currently at daily flow of ~80 gpm on weekdays (50% of design flow)
 - Expect to reach design rate at end of March 2018





Startup process interruptions resulting in on-going startup:

- Dewatering building operations Monday thru Saturday (utilize Equalization Tank volume on weekends)
- Blower baghouse maintenance blower/plant shutdowns (Fall 2016)
- Primary Digester contract work, loss of ability to make Class B biosolids
 - Mid December 2016 Centrifuge operation limited to once per week, sufficient to fill EQ tank and support minimum feed to ANITATM Mox
- Dewatering process equipment issues following contract work to upgrade facility and extended equipment outage (centrifuge fail, conveyor fail)
- Plant secondary treatment upset (September 2017), current winter start-up conditions, and no centrate treatment on-site prior to ANITATM Mox



Egan ANITATM Mox Media Progression







Treatment Plant Operators collect samples

- Daily samples for process control analyzed in TPO lab
 - Ammonia-N, Nitrate-N, Nitrite-N, pH, and Alkalinity
 - TPOs make process corrections and adjustment based on results
- Samples also submitted to District Analytical Lab Division (ALD) for similar and additional analyses and reporting – 3 to 5 times per week depending on parameters





- Daily sample results and 24-hr DCS trend data forwarded to the team consisting of Egan M&O operators, Kruger, and District Engineering and M&R staff
- Initially, process change recommendations provided by Kruger
- Currently, all process changes initiated by District operators, Kruger reviews results and trends and provides input as needed
- Process very robust: daily samples are sufficient for monitoring;
 once startup completed and stable operations established, daily sampling will be reduced to fewer weekly samples
- Process very robust: with centrifuge outages and the very low flow operations, system responds well when returned to continuous operation



Monitoring DCS Trends & Bench Sheets

AM Reactor 2 - HSR

11/19/2016 12:00:00.000 AM					
E55AIT5200A.UNIT0@NE REACTOR 2 AMMONIA-N	146.783	MG/L	Scale:	400	50.000 Actual Value
E55AIT5200B.UNITO@NE REACTOR 2 NITRATE-N	106.504	MG/L	Scale:	200	0.000 Actual Value
E55AIT5205.UNIT0@NET0 REACTOR 2 TEMPERATURE	87.820	DEGF	Scale:	120	32.000 Actual Value
E55AIT5202.UNIT0@NET0 REACTOR 2 PH	6.411	PH	Scale:	10.000	3.000 Actual Value
E55AIT5201.UNIT0@NET0 REACTOR 2 DO	0.105	MG/L	Scale:	3.000	0.000 Actual Value
E55FIT5203.UNIT0@NET0 REACTOR 2 AIRFLOW	0.527	SCFM	Scale:	800	0.000 Actual Value
E55FIT5053.UNITO@NET0 EQ CENTRATE TO FLOC FL	119.871	GAL	Scale:	350	0.000 Actual Value

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Process Control

- Reactors Effluent Ammonia-N range: 150-200 mg/L
 - Adjust the aeration rate
- Reactors pH (6.5-7.0)
 - Adjust the aeration rate
 - Adjust feed rate
 - Add alkalinity (soda ash)
- Reactors Nitrite levels (<10 mg/L)
 - Elevated nitrite-N undesirable to anammox bacteria and levels need to be kept low





Dosing for Alkalinity



- Egan uses ferric chloride in dewatering process; this reduces available alkalinity making centrate alkalinity deficient
- Supplement with Soda Ash





Improvements



- Equalization Tank operates at varying levels during process start-up, on weekends, and during low flow standby period conditions – probes designed for continuous full submergence
- Installed sample tank with small sample pump to recirculate centrate and get continuous instrument readings



Improvements

- Added a Suspended Solids probe to the centrate line from Dewatering to ANITATM Mox.
- Limited supervision of centrifuges on/off shifts.
 High suspended solids content detected to take centrifuge off production.



Alert control room so
operator can go correct
the operation and
prevent high solids from
reaching process (high
solids undesirable to
ANITATM Mox process).



ANITATM Mox Initial Startup (8/31/16-12/22/16)



Influent Ammonia-N: 938 mg/L; Effluent Ammonia-N: 159 mg/L; Ammonia-N Removal: 83%



ANITATM Mox Standby Period (12/23/16-8/15/17)









ANITATM Mox Startup Data –Ammonia Load from Sidestream and Plant Influent



ANITATM Mox Startup Data – Percent Ammonia Load from Sidestream





ANITATM Mox Startup Data – JEOUT NH3-N



JEOUT NH3-N is monitored twice per week.

Egan ANITATM Mox Reactor "Seed Carrier Biofilms"

- Little to no
 AOB/NOB signal on seeded carrier biofilms
- Strong anammox
 (AMX) signal
 distributed throughout
 the thickness of the
 biofilm
- Anammox signal is strongest at the bulk/biofilm interface and does seem to decrease closer to the carrier/biofilm interface



K5 Seed Carrier, Egan WRP ANITATM Mox Reactor, Sampled October 12, 2016 (Alex Rosenthal, Wells Group, Northwestern University)

Egan ANITATM Mox Reactor "New Carrier Biofilms"

- ~20-50 micron thick "patchy" anammox signal detected on new carriers
- AOB signal detected with varied spatial patterns of enrichment
 - Basal layer (see lower left corner)
 - Finger-like protrusions extending from the basal layer (often connected to anammox basal layer biofilm)
 - Some microcolonies embedded within dense anammox signal
- Very little **NOB** detected



K5 New Carrier, Egan WRP ANITA™ Mox Reactor, Sampled October 12, 2016 (Alex Rosenthal, Wells Group, Northwestern University)

Egan ANITATM Mox Reactor "Suspension"

- Apparent selective enrichment of **AOB**.
- A few **anammox** microcolonies observed in most micrographs
- Very low abundance of **NOB** signal
- SRT is seemingly high enough to support AOB enrichment in the reactor suspension



Suspended Solids, Egan WRP ANITATM Mox Reactor, Sampled October 12, 2016 (Alex Rosenthal, Wells Group, Northwestern University)



- 1. Daily sampling is helpful in preventing process upset
- 2. System can maintain activity even at very low flows for extended periods of time
- 3. Maintaining some activity during down times allows for less stressful restart
- 4. Installing a suspended solids probe upstream of the diversion valve to ANITATM Mox process allows for early detection of high solids and upstream equipment adjustment before centrate gets to the process
- 5. If EQ tank is to be operated at varying levels, consider location of instrumentation
- 6. If system is alkalinity deficient, having reliably working alkalinity dosing system will prevent back breaking manual dosing to keep up with system demand



- Successfully implemented ANITATM Mox into existing, unused basins with collaborations between Engineering, M&O, M&R Departments and Kruger.
- Nitrogen removal in sidestream has allowed flexibility to plant operations and should help mitigate odor problems in pipelines.
- Feeding the system at low flows while repair of mechanical equipment upstream assisted in secondary startup
- Startup expected to be completed by the end of March 2018
- Despite various challenges:
 - Ammonia removal has averaged greater than 75%
 - TIN removal has averaged greater than 65%
- This project provides the District with invaluable knowledge, experience and opportunity to move towards the Mainstream Deammonification; learned experiences of sidestream and mainstream Deammonification @ Egan WRP may be applied to other District facilities.

QUESTIONS?

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