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NEW ENGLAND WATER ENVIRONMENT ASSOCIATION
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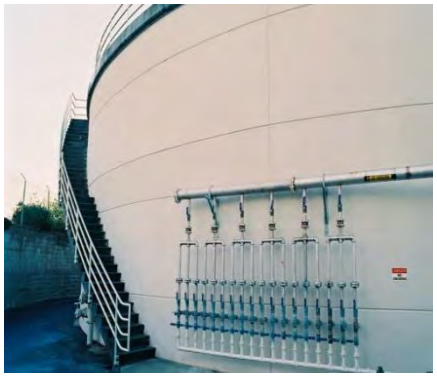
New Directions for Sidestream Nutrient Recovery at Municipal Water Resource Recovery Facilities

Camilla Kuo-Dahab | Varun Srinivasan



Agenda

- Introduction
- Case Studies
- Emerging and Innovative Technologies
- Beneficial Use of Recovered Nutrients
- Research Trends

Introduction

Importance of Nutrient Management

Regulatory and Global Drivers

- Environmental pollution
  - TN and TP effluent limits
    - Some plants already have TN and TP effluent limits
    - Future TN and TP limits
  - TN and TP limits for land application of biosolids
- Growing populations and cost/demand of mineral fertilizer
  - Limited global supply of P (phosphate rock)
- Paradigm shift to a circular economy
  - Evolution of WRRF to Biorefineries

Definition and Characteristics of Sidestreams

- Flow resulting from treatment of biosolids that is returned to liquid treatment train
  - Filtrate
  - Centrate
  - Thickener filtrate
  - Digester supernatant
  - Filter backwash
- Typically intermittent flow, can be small
- Can contribute significant nutrients (N and P) loading to liquid treatment train
  - Based on influents

Why Sidestream Treatment?

- Recovers nutrients for beneficial reuse
- Reduced N and/or P to liquid treatment train
  - Less power and smaller carbon footprint
  - More stable operations
  - Lower effluent nutrient limits met
- Reduced volume or nutrient content of biosolids
- Reduced struvite formation
- Can be economical when sidestream constitutes:
  - At least 15% influent TN loading
  - At least 20% influent TP loading
  - Significant biological treatment of solids (i.e., digestion)

Is Sidestream Treatment Right for your Facility?

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Types of Evaluations

- High-level with limited data
- High-level BioWin Modeling with limited data
- In-Depth BioWin Modeling with specified data collection
  - Wastewater characterization
  - Calibrated model
  - 3-6 months of plant operating data with analysis

Case Study 1

- Regional biosolids processing facility
- Anaerobic digestion
- Solids:
  - Primary sludge
  - BAF sludge
  - Secondary sludge
  - Imported cake
  - SSO (food waste)
  - FOG

Case Study 1

	Average Annual	Max 30 Day	Max 14-Day	Max 7	Max Day
Plant Influent					
Peaking Factors	1.00	1.26	1.40	1.50	1.69
Influent Flow (MGD)	0.59	0.74	0.82	0.88	0.99
Influent TKN (mg-N/L)	41	41	41	41	41
Influent Phosphorus (mg-P/L)	10	10	10	10	10
Plant Load (lb-N/day)	198	249	277	297	335
Plant Load (lb-P/day)	49	62	68	73	83
Baseline					
Filtrate Return N Load (lb-N/day)	**1,115**	**1,083**	**1,184**	**1,255**	**1,391**
Filtrate Return P Load (lb-P/day)	**47**	**52**	**57**	**61**	**68**
Filtrate Return Load- Percent of Plant N Load (%)	563%	434%	427%	423%	416%
Filtrate Return Load- Percent of Plant P Load (%)	97%	85%	84%	83%	82%
Regional Biosolids Processing Facility					
Filtrate Return N Load (lb-N/day)	**6,520**	**6,461**	**6,577**	**6,660**	**6,817**
Filtrate Return P Load (lb-P/day)	**806**	**780**	**802**	**818**	**847**
Filtrate Return Load- Percent of Plant N Load (%)	3294%	2591%	2374%	2243%	2038%
Filtrate Return Load- Percent of Plant P Load (%)	1650%	1267%	1172%	1115%	1026%

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Case Study 2

- Single facility treating 36 MGD→ Regional biosolids processing facility
- Anaerobic digestion
- Wastes:
  - Primary sludge
  - Secondary sludge
  - Imported cake
  - Imported sludge
  - High strength waste

Case Study 2

Digestion Scenarios Liquid Stream Impacts						
		Status Quo	Additional sewered waste	+ Imported Wastewater Solids	+ HSOW	+ Imported Wastewater Solids + HSOW
Plant influent						
Flow	mgd	36				
cBOD5	mg/L	255				
TSS	mg/L	195				
TKN	mg N/L	23				
Ammonia	mg N/L	12				
Total phosphorus	mgP/L	5				
Primary effluent						
Flow	mgd	36.1	36.1	36.1	36.1	36.1
TKN	mg N/L	20	24	24	24	24
Ammonia	mg N/L	12	16	16	17	16
Total Phosphorus	mgP/L	4.1	7.2	7.2	7.5	7.4
Aeration Basins						
MLSS	mg/L	2,450	2,500	2,530	2,510	2,520
Oxygen transfer rate	lb/hr	3,010	3,115	3,110	3,140	3,130
Final Effluent						
Ammonia	mg N/L	0.2	0.1	0.2	0.1	0.1
Nitrate and Nitrite	mg N/L	3	5	5	6	6
TN	mg N/L	5	7	7	7	7
Alkalinity	mg CaCO3/L	80	69	70	68	69
Total phosphorus	mgP/L	0.3	2.0	1.9	2.2	2.2

Case Study 2

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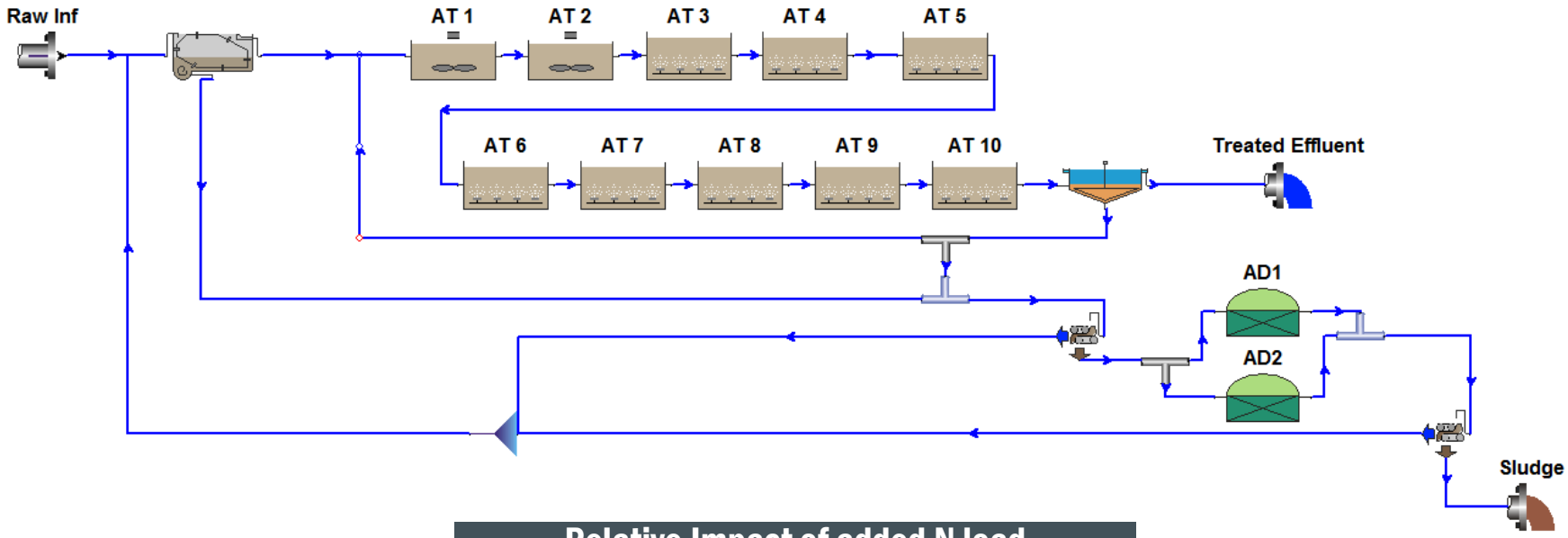
TN	mg N/L	5	7	7	7	7
Alkalinity	mg CaCO3/L	80	69	70	68	69
Total phosphorus	mgP/L	0.3	2.0	1.9	2.2	2.2

Case Study 3

- Single facility treating 20 MGD
- Anaerobic digestion
- Solids:
  - Primary sludge
  - Secondary sludge
  - Food waste centrate

Case Study 3



Relative Impact of added N load	
Parameters	% Changes (+/-)
Primary Effluent N load	+4.6
Primary Sludge Load	+1.2
MLSS	+0.3
Secondary Effluent NH_4	No change
Secondary Effluent TP	+4
Airflow requirements	+ 7
WAS load	+0.2

Technologies

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Treatment Technologies

Biological

Nitrification / Denitrification
& Bio-augmentation

- In-Nitri
- AT#3
- BABE
- MAUREEN
- ScanDeNi

Nitritation / Denitritation

- SHARON
- Ana-Aer
- PANDA

De-ammonification

- Strass Process
- ANAMMOX
- Attached Growth (AnitaMox)
- DEMON
- CANON
- OLAND
- DeAmmon
- ELAN
- Cleargreen
- TERRAMOX

Physical-Chemical

Ammonia Stripping

- Steam
- Hot Air

Ion-Exchange

- ARP Process

Struvite Precipitation

- Ostara/AirPrex Process
- MAP Processes
- Pe-Phlo System
- NuReSys Process

Emerging Processes and Technologies

- Solid-liquid separation up-front in a treatment train
  - High-rate-solid-liquid separation followed by biological treatment of ammonia in separated liquid fraction
- Quick Wash Process
  - Acidification of organic solids to release phosphate and precipitation of phosphate as calcium phosphate
- Pyrolysis and gasification processes
- Capture and recovery of gaseous ammonia (NH_3)
  - Gas-permeable membranes (GPM)
  - GPM with anaerobic digestion
- Microalgae based processes

Beneficial Use of Recovered Nutrients

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Beneficial Use

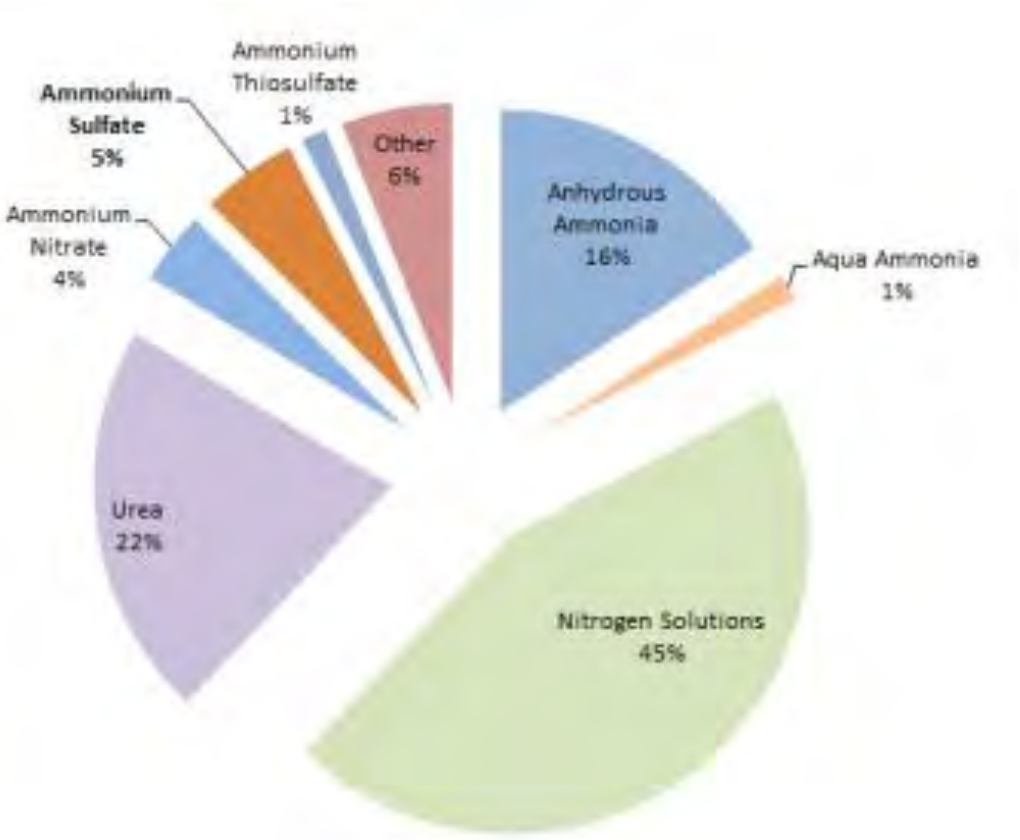
- Recovery consists on producing new material flows which subsequently can be reused (i.e., as agricultural fertilizer)
- Needs to be in a form that is acceptable by intermediary that incorporates the recovered product (i.e., fertilizer blender) or by the end user for direct application (i.e., farmer)

Uses of Recovered Products

- Fertilizer (Commercial)
  - Ammonium nitrate, sulfate, chloride, phosphates (struvite)
- Fuel Source
  - Alternative to liquid fuel
  - Contains no carbon- no GHG emissions
  - Can power diesel, spark-ignited IC engines, direct ammonia fuel cells, combustion turbines
- Emerging Products
  - Medium Chain Fatty Acids (MCFAs) that can be used in the biofuel industry

Nitrogen Fertilizer use in the US

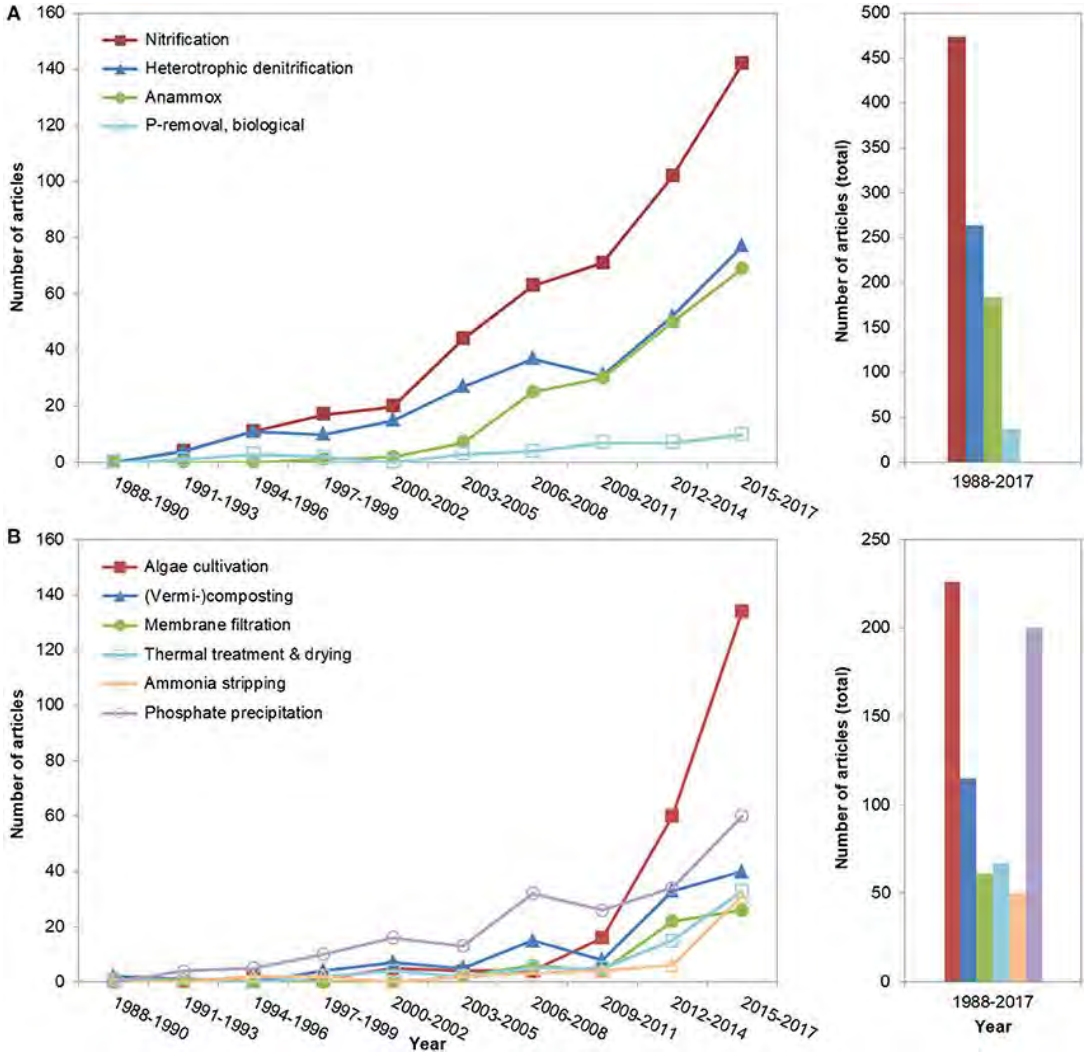
- Aqueous solution market is the largest in the US
- Use of ammonium sulfate has been steadily growing



Data from AAPFCO, 2007

Research Trends

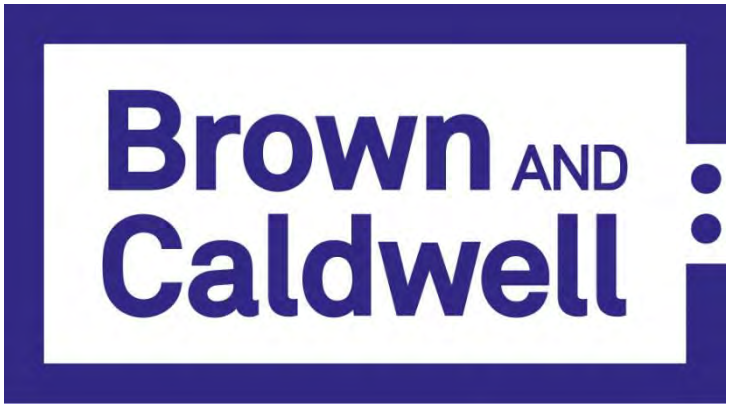
Research Trends



Research Needs

- Lower cost nutrient removal methods
- Better understanding of biological processes to provide more efficient and reliable designs
- Marketability of ammonium recovered products from WRRFs
- Plant operating schemes or conditions that increase economic viability of struvite crystallization and recovery processes


Thank you.
Questions?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Case Study 4

- Single facility treating 2.5 MGD
- Anaerobic digestion
- Solids:
  - Wastewater solids
  - Tertiary filtration solids
  - SSO (food waste)

Case Study 4

Estimated Nutrient Load Contribution of Food Waste to the Influent Load		
Parameter	Average annual	Maximum 30-day average
Digester Total Soluble Ammonia [a, b, c, d]		
Current plant ammonia-N load, lb-N/d	362	534
Food waste generated ammonia-N load, lb-N/d	189	189
Digester Total Soluble P [c, d, e, f, g, h,i]		
Current plant P load low (lb-P/day)	8.44	N/A
Current plant P load high (lb-P/day)	25.3	N/A
Food waste generated P load, lb-P/d	30	N/A

Recovered Ammonium Products

- **Ammonium sulfate (AS)**
  - Primary use of AS is fertilizer but no established market for AS from WRRFs
  - AS can be used in direct application or can be blended in custom fertilizer solutions
- Ammonium nitrate
  - Used extensively throughout the world, available in dry and liquid form
  - Used for explosives so strictly regulated
- Aqueous ammonia
  - Used by power plants
  - Difficult to store, health and safety risks
- Magnesium ammonium phosphate hexahydrate→ **Struvite**
  - Recognized fertilizer for more than 150 years
  - Slow release fertilizer
  - Struvite market dominated by soluble urea-aldehyde products and polymer and sulfur products
  - Demand increasing around the world