Wastewater Global Service Team

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Nutrient Recovery from Sewage Sludge Incinerator (SSI) Ash

by

Todd Williams, P.E.

May 16, 2016

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Acknowledgements:

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Agenda

- Overview of Nutrient Recovery from SSI ash
- Research status
- Promising technologies
- Summary

Introduction

- With ever increasingly stringent nutrient emission limits in the wastewater from Water Resource Recovery Facilities (WRRF), wastewater engineers are faced with the challenge of reducing nutrients in the effluent.
- Techniques for reducing phosphorus include biological phosphorus removal (BPR) and chemical removal.
- In both cases, phosphorus, sequestered in the sludge, may be processed to produce biosolids or incinerated to produce an ash.
- While processes to recover phosphorus are well established, processes for recovering phosphorus from ash are not well known
- With a large proportion of existing SSIs in the U.S. located in New Jersey, there is an opportunity move SSI from an energy recovery technology to a resource recovery technology.

Why consider recovering P from SSI Ash?

- Unlike dewatering centrate, P is concentered in SSI ash
- SSI ash mainly consists of SiO_2, P_2O_5, Fe_2O_3 and CaO.
- P can be beneficially used as a fertilizer
- SSI ash also contains heavy metals which must be removed from the final fertilizer product

Elemental Analysis of Ash %				
SiO_2	23.51	26.73	21.34	26.52
AL_2O_3	8.16	8.49	9.31	8.64
TiO_2	1.28	1.38	1.43	1.49
Fe_2O_3	12.21	9.65	10.16	10.06
CaO	12.2	12.8	14.6	13.4
MgO	5.75	6.41	6.36	6.56
Na_2O	1.33	1.38	1.43	1.41
K_2O	3.44	3.01	3.24	3.00
P_2O_5	27.12	25.52	24.8	25.63
SO_3	0.05	0.93	1.5	1.18
Cl	0.02	0.02	0.04	0.02
CO_2	0.04	0.21	0.23	0.21

Development of P recovery from SSI Ash

- On-going work in Europe and Japan
- Japanese research undertaken at Chuo University, Tokyo
  - Showed ability to recover P from SSI ash, using an Enhanced Biological Phosphorus Removal laboratory rig.
- European research presented at 2 conferences in 2009
  - Conference on Nutrient Recovery from Wastewater Streams in Vancouver (Canada) in May 2009
  - Baltic 21 - *Phosphorus Recycling and Good Agricultural Management Practice,* ***Berlin September 2009***

Japanese Study (published 2001)

- Bench-top study of P recovery from SSI ash
- Used sulfuric acid extraction, followed by alkali addition and filtration
- More than 90% of P in ash was recovered
- Heavy metals from acid addition were also separated from the P

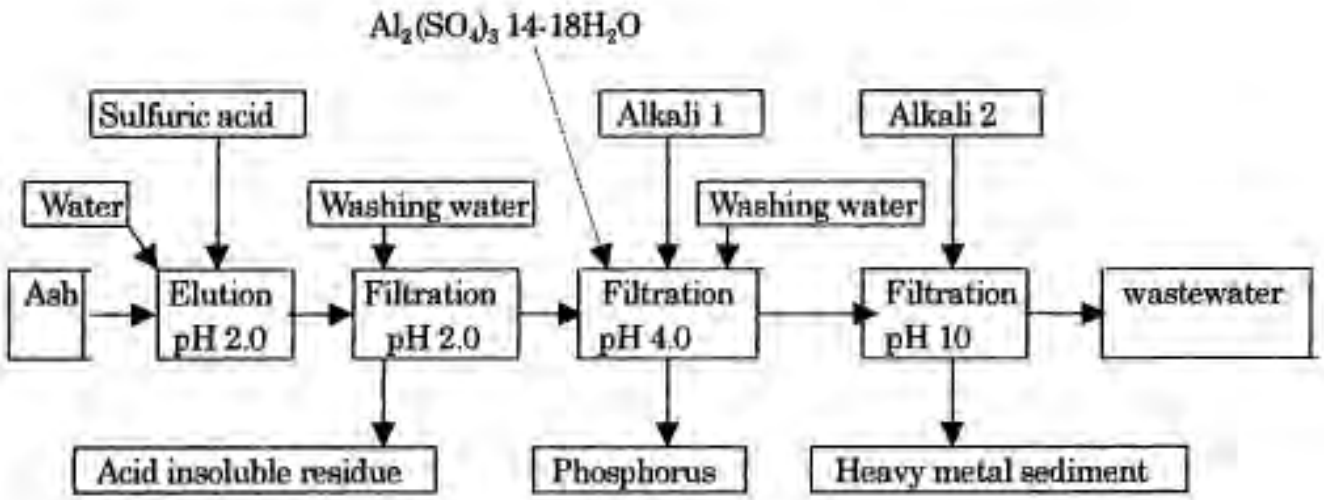


Fig. 1. Basic procedure.

German National Research & Development Initiative

- "Recycling management of plant nutrients, especially phosphorus"
- launched 2005

Federal Ministry of Education and Research

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Coordination

- Project Management Agency Forschungszentrum Karlsruhe, Water Technology and Waste Management Division
- German Federal Environment Agency
- runtime: 2006 - 2011

German National Research & Development Initiative (continued)

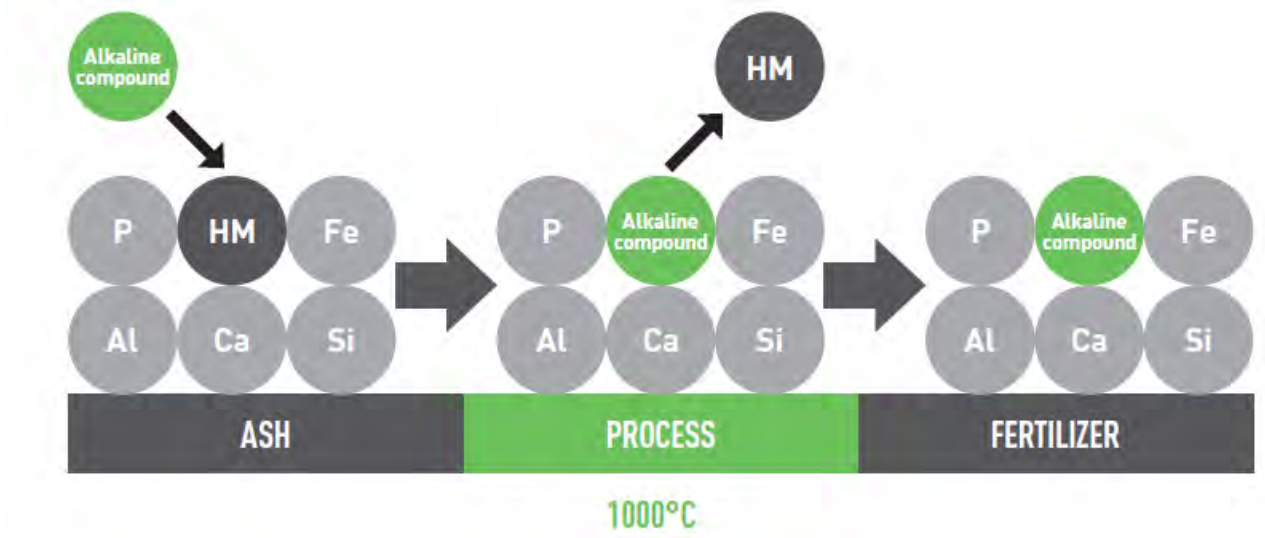
Technical cooperative projects (1/2)

- PASH: Recovery of plant nutrients, especially phosphorus from sewage sludge ash
  - RWTH Aachen University
  - Aachen University of Applied Sciences,
  - ATEMIS GmbH
- PHOXNAN: Optimised phosphorus recycling from wastewater sludge by the combination of low pressure wet oxidation and nanofiltration
  - Bayer Technology Services
  - RWTH Aachen University
- PROPHOS: Phosphorus recovery from wastewater, sewage sludge and incineration ash
  - Darmstadt University of Technology
  - University of Karlsruhe
  - Gottfried Wilhelm Leibnitz University Hannover
- RECYPHOS: Phosphorus recycling – Substainability contribution to decentral wastewater treatment
  - TU Dresden
  - BTU Cottbus
  - Bergmann Waste Water Engineering
- PHOSIEDI: Phosphorus Recovery using Ion-Exchange and Electrodialysis
  - University of Karlsruhe

Summary of P Recovery Technologies/Research on SSI Ash

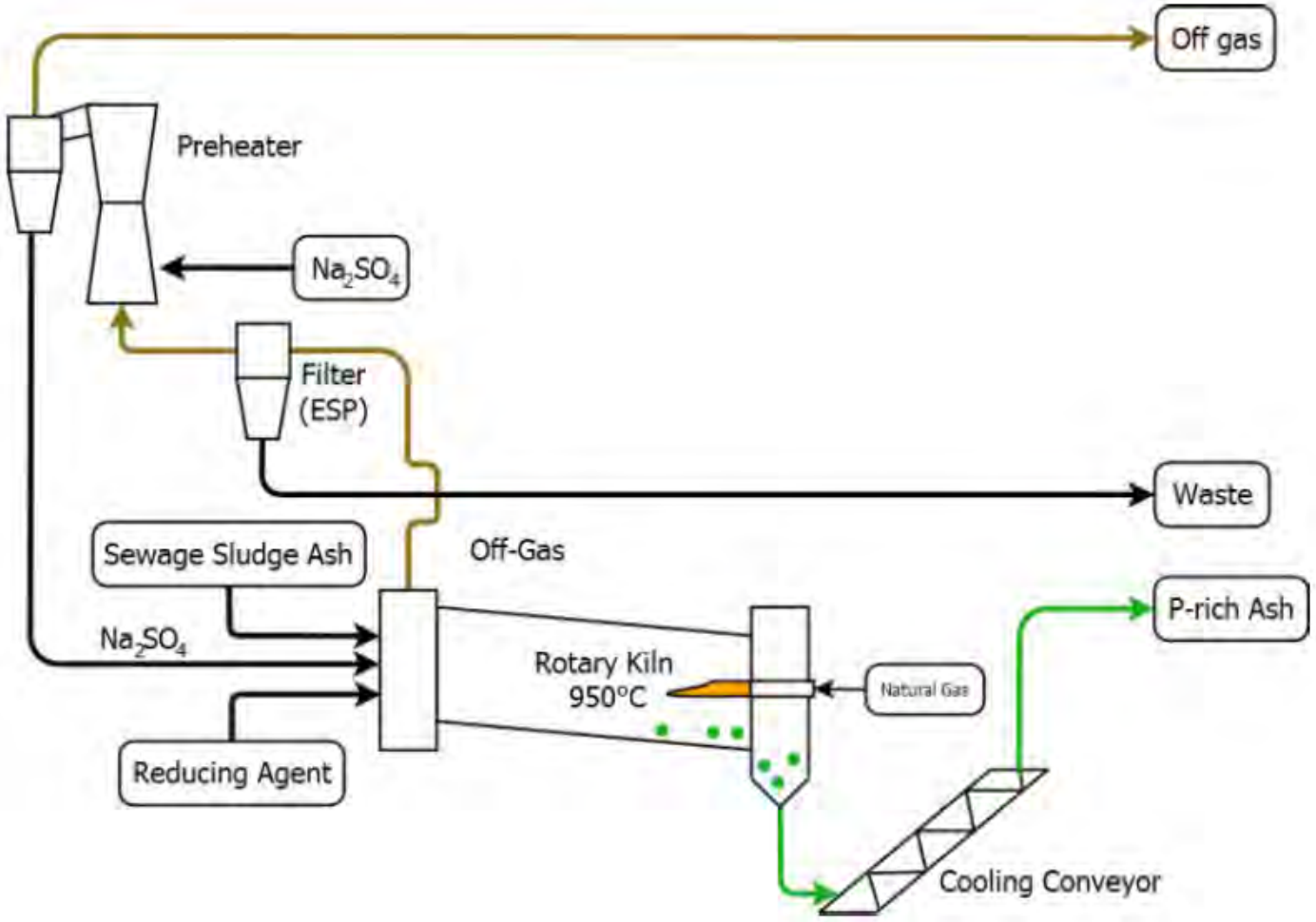
- Japanese – Sulfuric acid extraction and alkali addition/filtration
- European
  - AshDec (discussed following)
  - PASH (discussed following)
  - Biocon
  - Prophos

The ASH DEC Process



- uses thermo-chemical treatment to produce renewable phosphate for fertilizer production
- includes mixing of ashes and chlorine donors and subsequent treatment in rotary kiln for 20 min at temperature of 900 – 1,050 ^{o}C
- the heavy metals evaporate and P-rich product is obtained
- the toxic substances are retained in air pollution control system in the form of mixed metal hydroxides

The ASH DEC Process



Agricultural Aspects of Thermo-chemical Product

- Highly bioavailable Mg-phosphates are formed when MgCl2 used as Cl-donor
- Fertilization performance of those ashes are close to superphosphate
- Lower yield when $CaCl_2$ used as Cl-donor → post processing expedient
  - addition of a completely digested P (i.e. TSP) improves agricultural performance (dry matter yield and P-uptake)
  - like partial digestion with H_3PO_4, amendment of TSP results in chemical transformation of treated ash → brushite becoming dominating crystalline structure
- P availability in plant experiments was reflected best by extraction with alkaline ammonium citrate

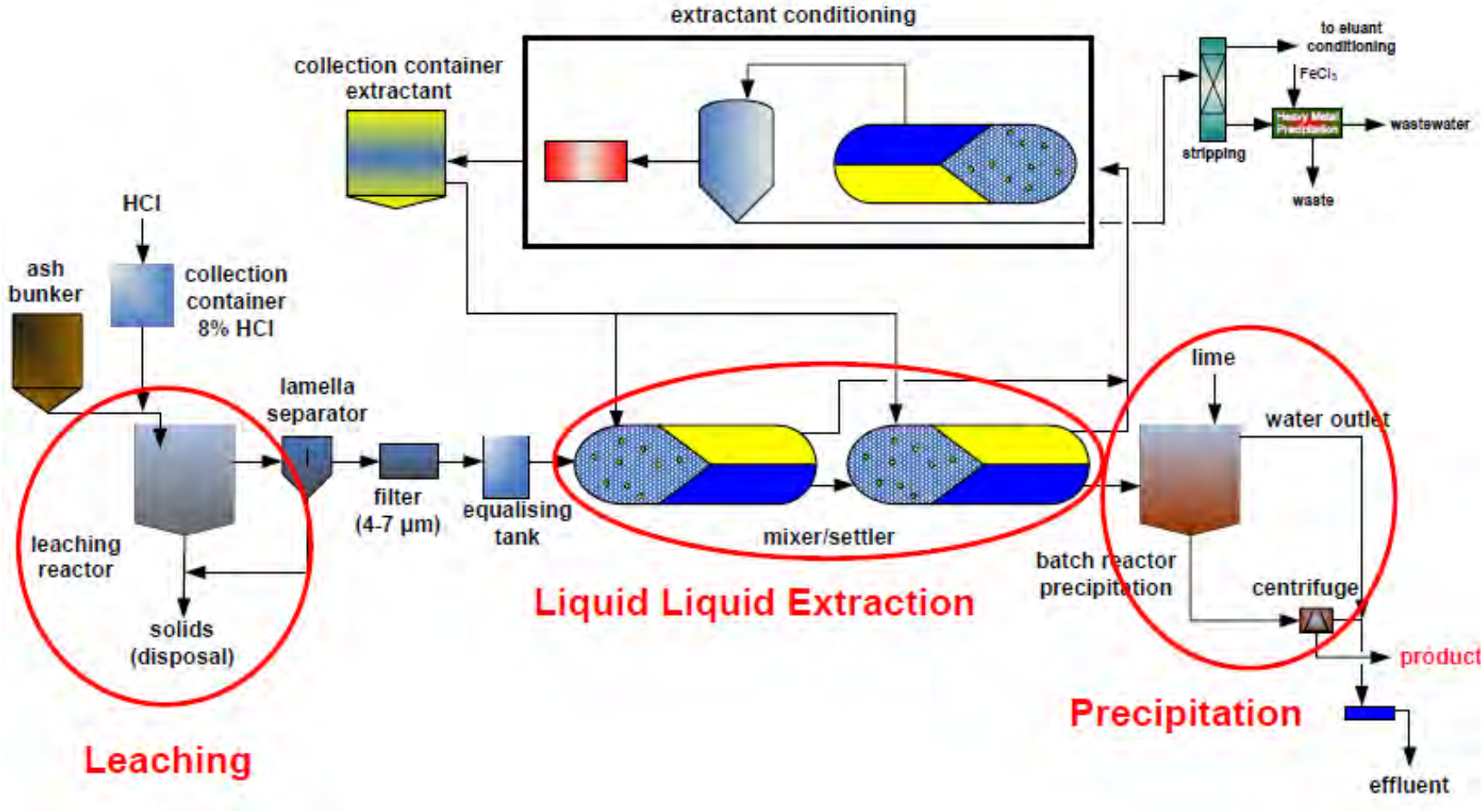
ASHDEC - Status

- Pilot tested at 7 t/d ash
- Outotec own the process and are reported to be building a P recovery plant
- The minimum size of plant offered by Outotec is 15,000 mt/yr ash or about 140 t/d dry solids to incineration
- Costs are unknown

PASH Process – Phosphorus recovery from Ash

- Wet chemical process developed at RWTH Aachen University
- P is extracted from SSI ash by acid leaching with HCl
- P is precipitated from the acidic solution by increasing the pH with lime → main constituents are calcium- and aluminum- phosphates
- investigations in laboratory and pilot scale
- P-recovery potential of 90%
- costs: approx. $3.50/kg P recovered

PASH Flowsheet (Simplified)



Status of PASH

- PASH has been pilot tested
- Waiting to be commercialized
- Projected cost is approx. $3.50/kg P

Summary

- SSI ash contains P which has been concentrated
- P recovery from SSI ash has been pilot tested, however, the only full-scale technology offered is ASHDEC by Outotech
- Recovery of P from SSI ash provides a future opportunity to recover a valuable fertilizer nutrient and recycle it into the environment
- Likely, there will need to be regional facilities to make the recovery more affordable.

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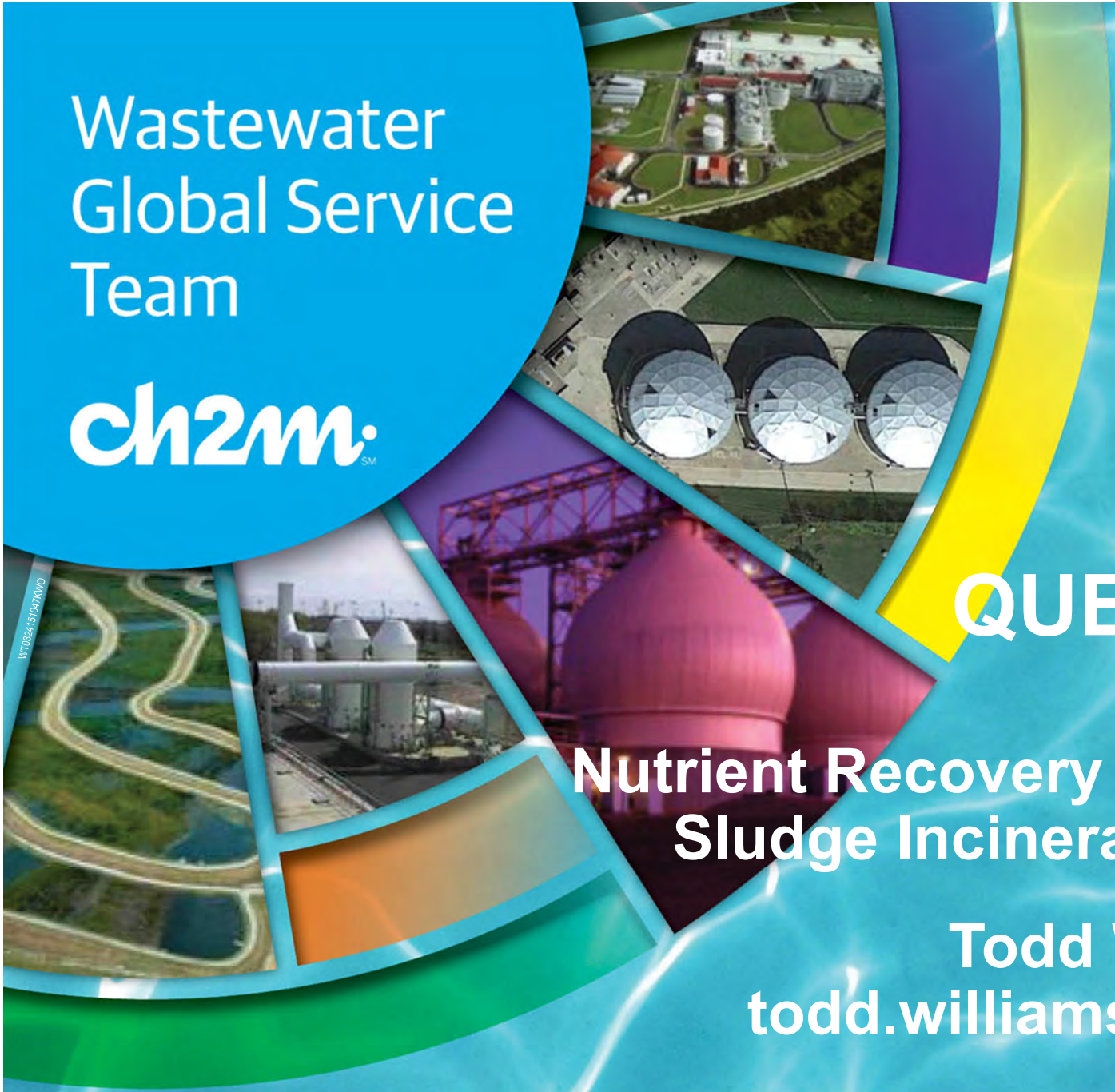

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QUESTIONS?

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