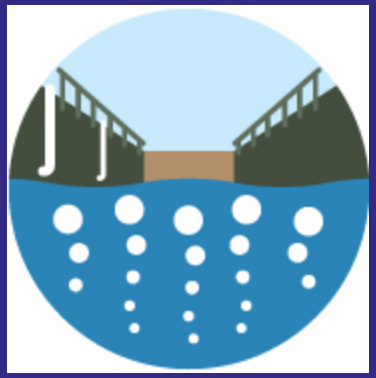


Management Challenges Caused by Unique Solids Characteristics in BNR Treatment Plants

26th Annual Conference on the Environment

11/9/2011

Lloyd Winchell – Brown and Caldwell

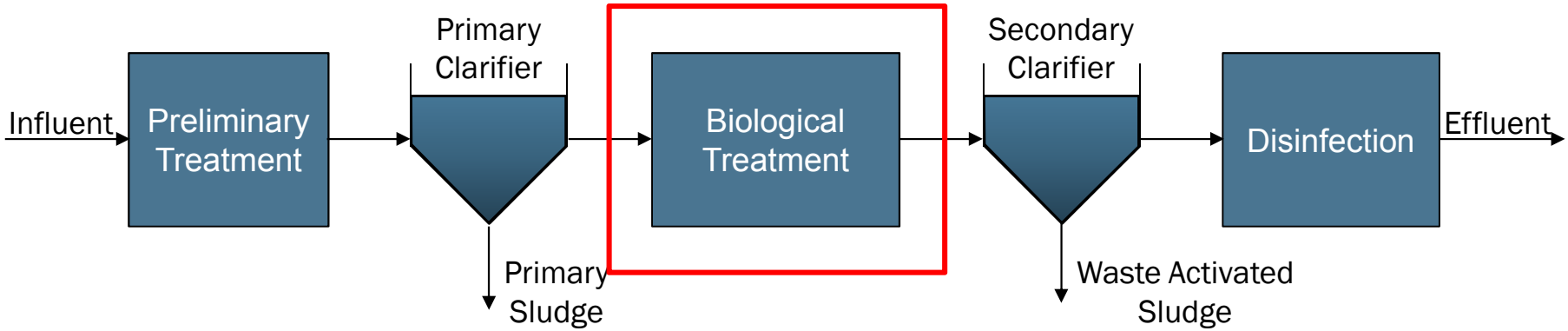
Brown AND Caldwell

Outline

1. Treatment Process Background
   a. BNR
   b. BioP
2. Solids Handling Challenges
   a. Digestion Impacts
      i. Struvite Formation
      ii. Cationic Implications
   b. Incineration Complications
      i. Eutectics

Treatment Process Background – BNR

- BNR = Biological Nutrient Removal

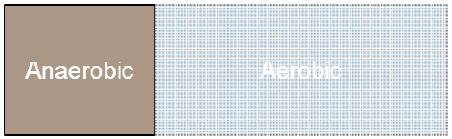


- Conventionally focused on BOD removal and nitrification
- Nutrient limits becoming more stringent, principally N and P
- Focus on phosphorus (P) removal

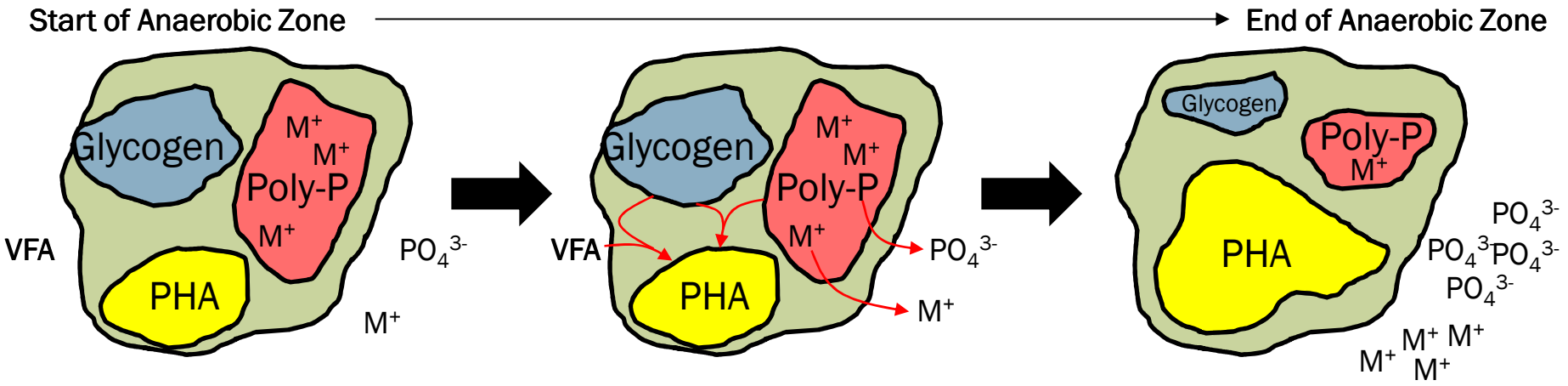
University of Michigan. "EcoFore 2006: Assessing the causes, consequences and remedies for hypoxia in Lake Erie" http://snre.umich.edu/scavia/ecofore/ (23 October 2011)

Treatment Process Background – Biological Phosphorus Removal

Anaerobic Zone



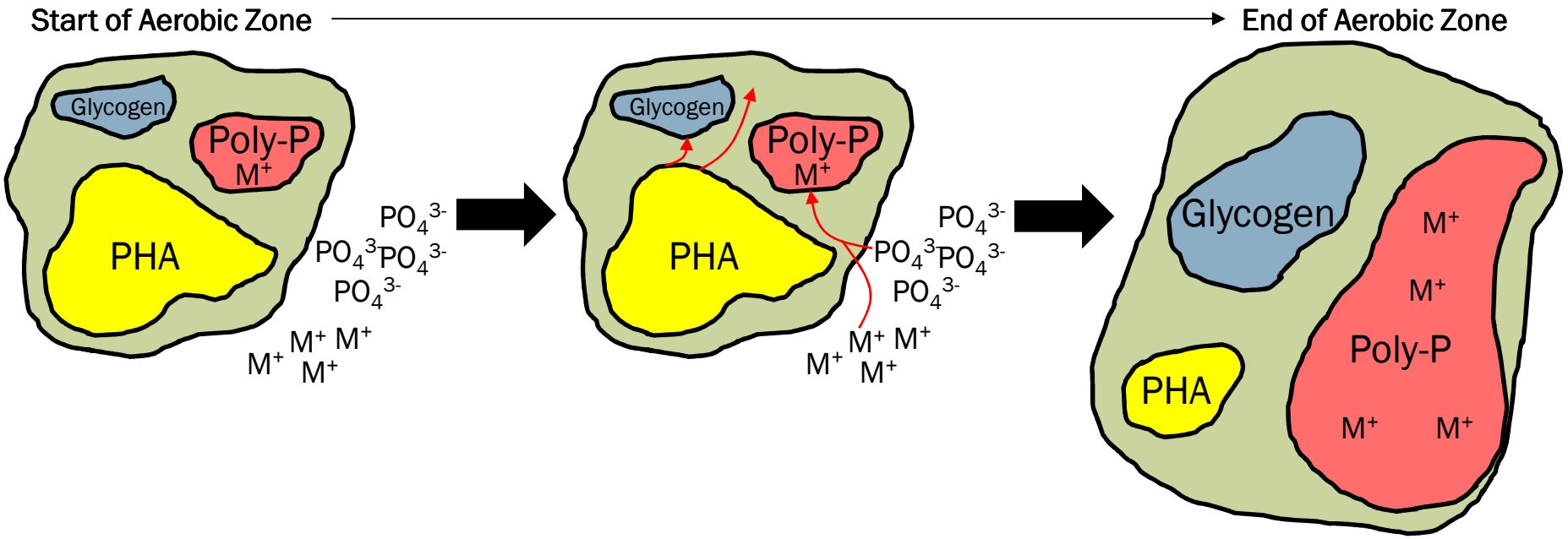
- Metabolize volatile fatty acids (VFAs) and store as energy (PHA)
- Release PO_4^{3-} and cations (M^+ = K^+, Mg^{2+}, and Ca^{2+}) to wastewater



Treatment Process Background – Biological Phosphorus Removal

Aerobic Zone

- PHA oxidized to form polyphosphate, incorporate PO_4^{3-} and M^+
- Settle PAOs to remove P from liquid stream



Treatment Process Background – Biological Phosphorus Removal

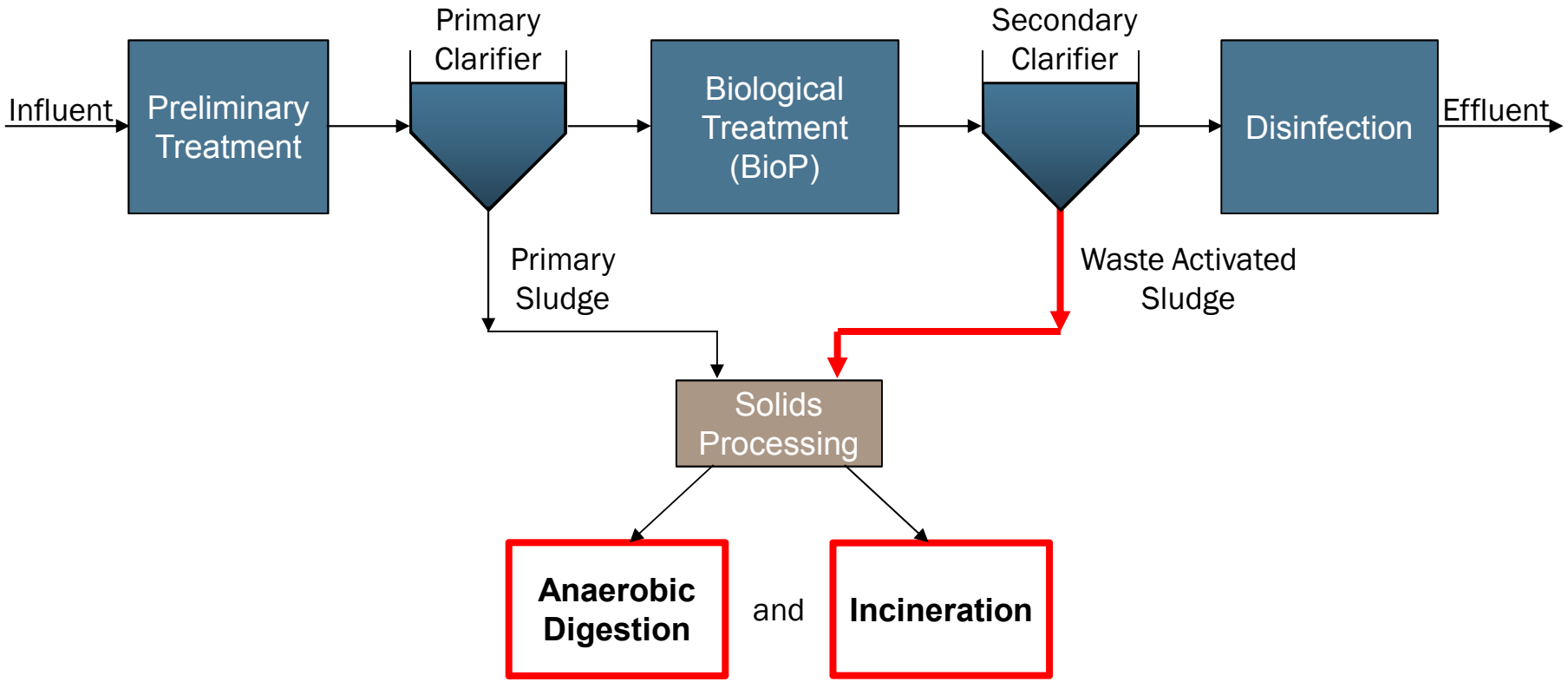
- Two key concepts

Assimilating
Excessive

→ P (2X conventional, min)

→ Cations

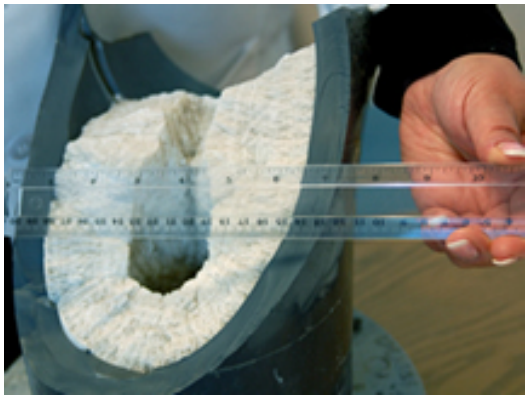
Process Configurations for Discussion



Anaerobic Digestion – Struvite

- $\underline{Mg}NH_4\underline{P}O_4*6H_20$
- BioP can increase formation potential 2-3 times (Esping and Merlo, 2011)
- Recover for fertilizer
  - Global phosphate rock resources will likely be depleted in next century at current consumption rate
  - WWTP recovery operating at full scale

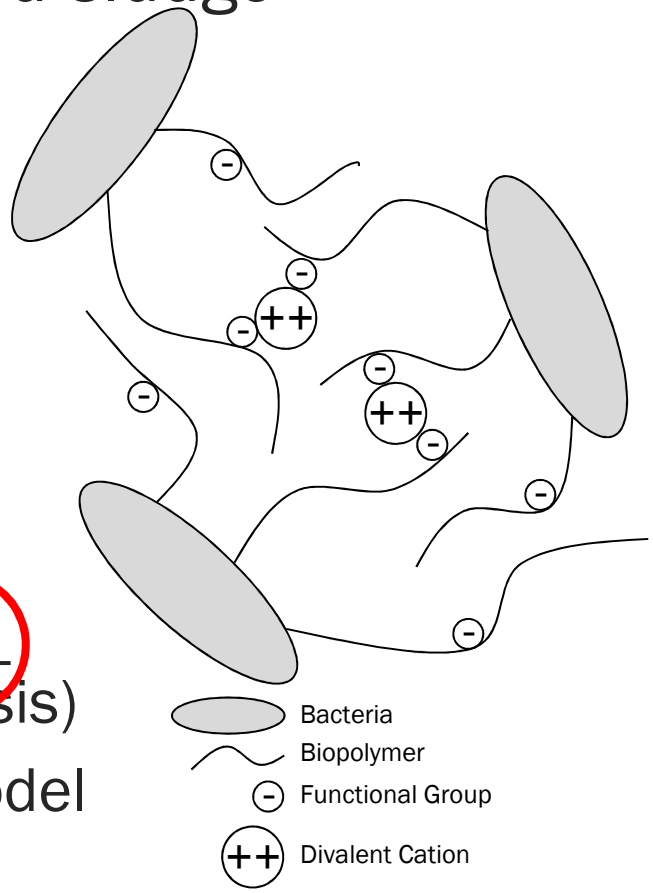
Gilbert, N. "Environment: The disappearing nutrient" http://www.nature.com/news/2009/091007/full/461716a.html (1 November 2011)



"Struvite Removed from Digesters to Restore Biosolids Treatment Capacity" *http://www.dsrsd.com/invest/reducecostincreaseefficiency.html (1 November 2011)*

Anaerobic Digestion – Cationic Implications

- Anecdotal evidence suggests cation balance can affect dewatering of anaerobically digested sludge
- Evidence:
  - Activated Sludge
    - Higgins & Novak (1997)
    - Ca^{2+} and Mg^{2+} addition significantly improved floc strength, settling, and dewatering
    - Na^{+} and K^{+} had negative impact
    - Monovalent/Divalent cation ratio 2/1 maximum for good properties (eq basis)
    - Proposed divalent cation bridging model



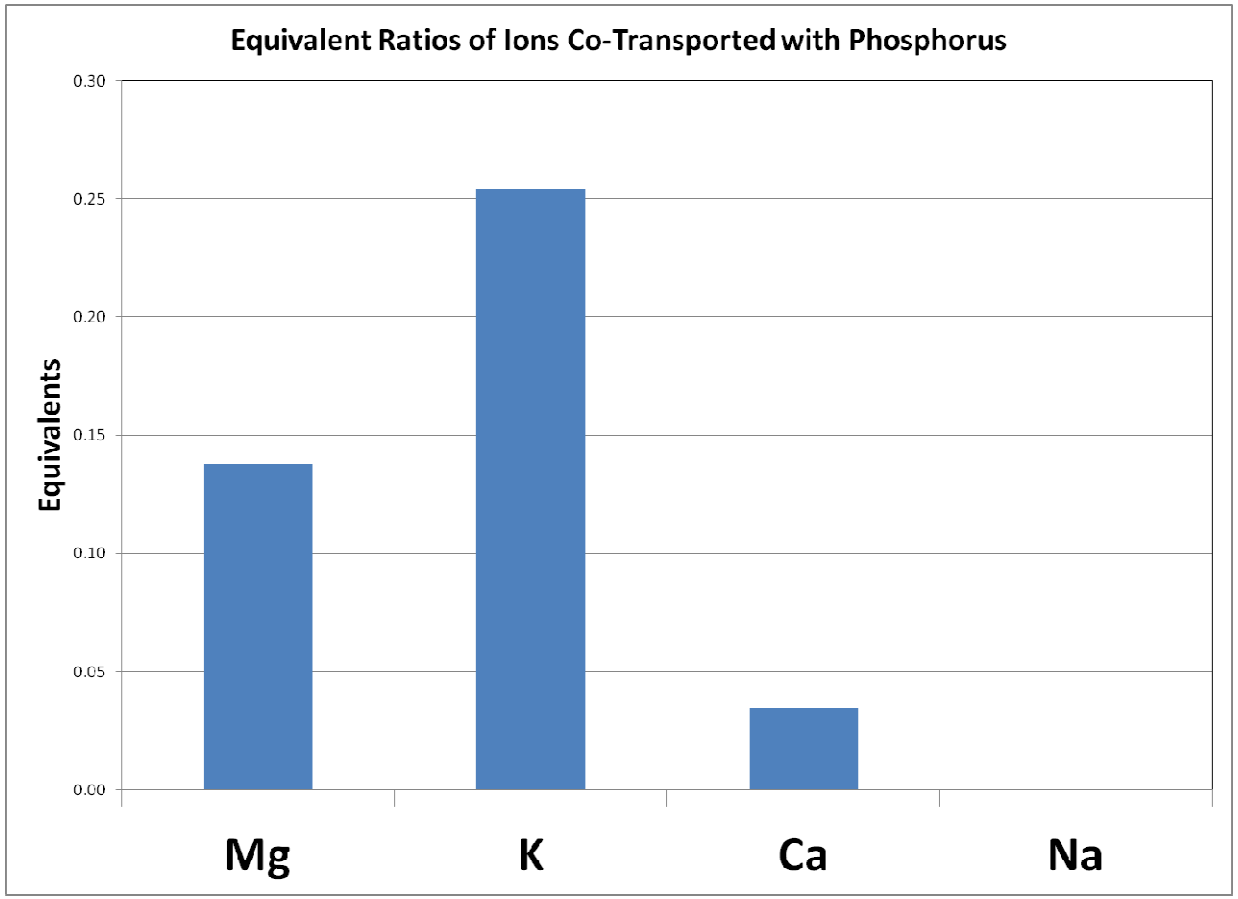
Adapted. Sobeck and Higgins (2002).

Anaerobic Digestion – Cationic Implications

- Activated Sludge (Higgins & Novak continued)
  - Ca^{2+}/Mg^{2+} equal to 1 important in some systems
  - Subsequent studies support cation importance
  - Murthy, et al (1998), and others, showed NH_4^+ had similar impacts as Na^+ and K^+
  - Limited full scale experience, but followed lab trends
- Aerobically Digested Sludge
  - Murthy and Novak (1998) found divalent cations important
  - Murthy, et al (1998) found similar trend predicted by M/D
- Anaerobically Digested Sludge
  - Novak and Park (2010) and personal communication - no M/D research
  - Hypothesis - achieving proper M/D would assist dewatering

Anaerobic Digestion – Cationic Implications

- BioP Implications

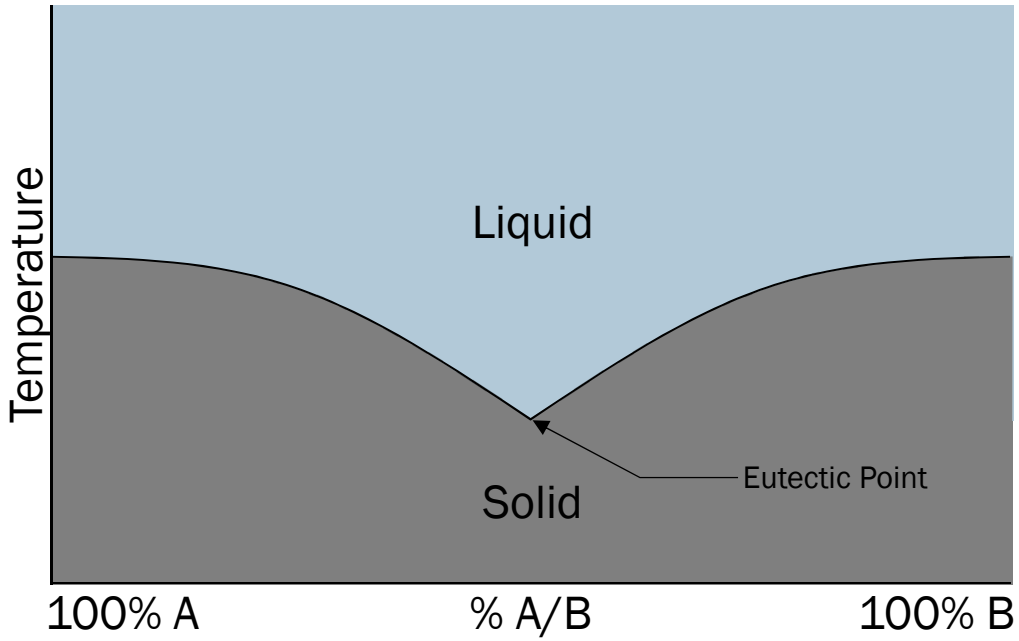


Anaerobic Digestion – Cationic Implications

- BioP Implications
  - Digested BioP sludge releases cations
    - M/D $\rightarrow$ 1.49
    - Ca/Mg $\rightarrow$ 0.25
    - Preferential uptake of Mg may impact sludge dewatering characteristics
  - After digestion:
    - M/D $\rightarrow$ 7-20 from NH_4^+ production
    - Suggests dewatering not optimal
- Divalent cation addition worth investigating

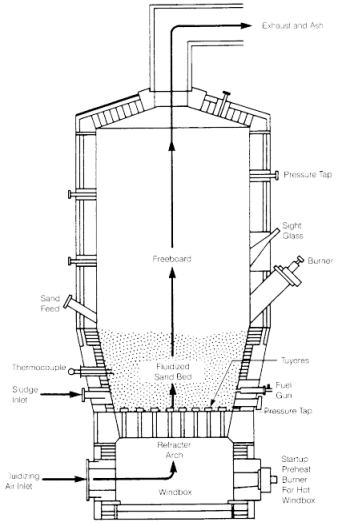
Incineration – Eutectics

- Eutectic – a mixture of compounds or elements that has a single composition that solidifies at a lower temperature than all other compositions.

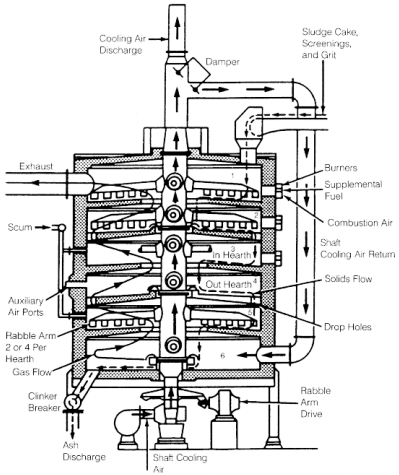


Incineration – Eutectics

- Eutectics cause agglomeration/slagging
  1. FBI – defluidization
  2. MHI – clinkers
  3. Scale - heat recovery loss, structural integrity
- Cl, Fe, P, K, Na, and SO_4 known eutectic elements found in sludge
- 3 tested BioP facilities exhibited eutectic activity at 1,400– 1,600 °F
- FBI/MHI operate at 1,400–1,600 °F



Fluidized Bed Incinerator

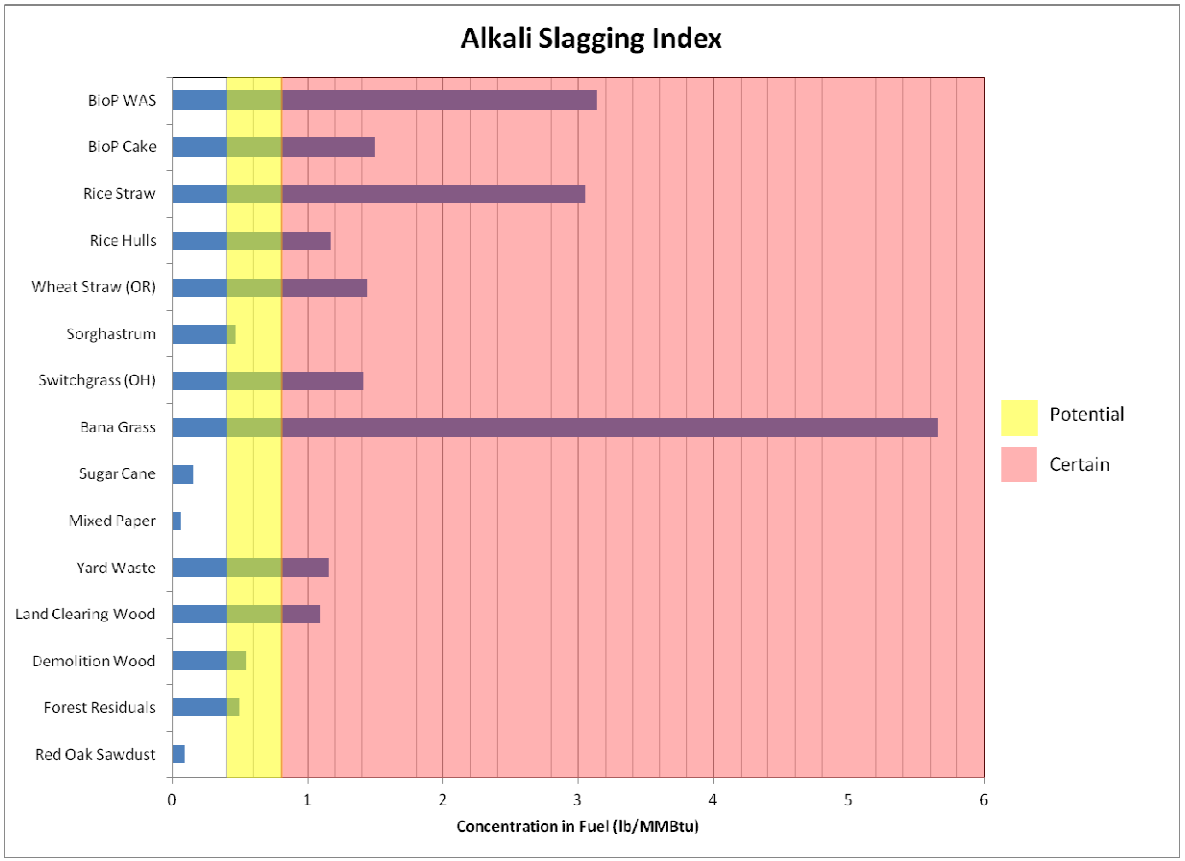


Multiple Hearth Incinerator

Sludge Incineration: Thermal Destruction of Residues. Manual of Practice FD-19. Water Environment Federation. Alexandria, VA. 1992

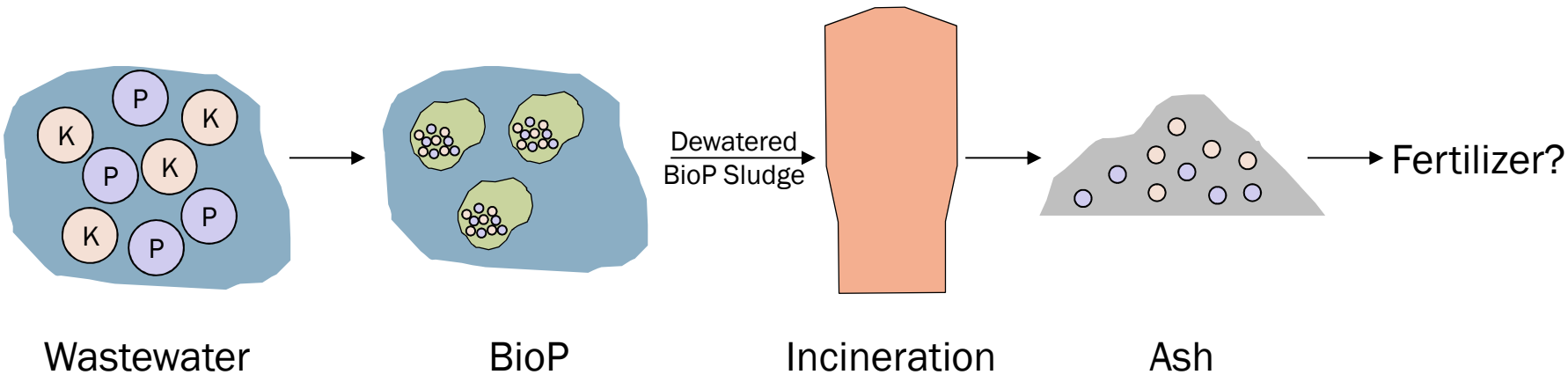
Incineration – Eutectics

- Coal industry developed alkali ($Na_2O + K_2O$) per unit heat index to predict fuel slagging tendencies



Incineration – Eutectics

- If slagging issues are anticipated/experienced metal oxides (principally CaX) or kaolin clay can be used to raise eutectic points
- Successful full scale installations
- P and K ultimately end up in ash – potential fertilizer?



Summary

- BNR, more specifically BioP, operation impacts solids handling
- Digestion
  - Struvite formation a primary concern
  - Dewatering may be impacted (adjust cation balance)
- Incineration
  - Eutectic compounds will impact operation, specific amendments can overcome issues

Acknowledgements

- Michael Macaulay and Mike Beattie (Brown and Caldwell)

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Questions