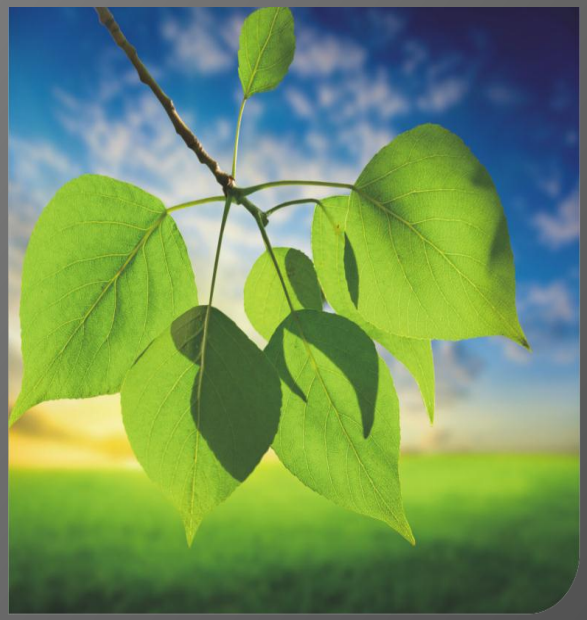



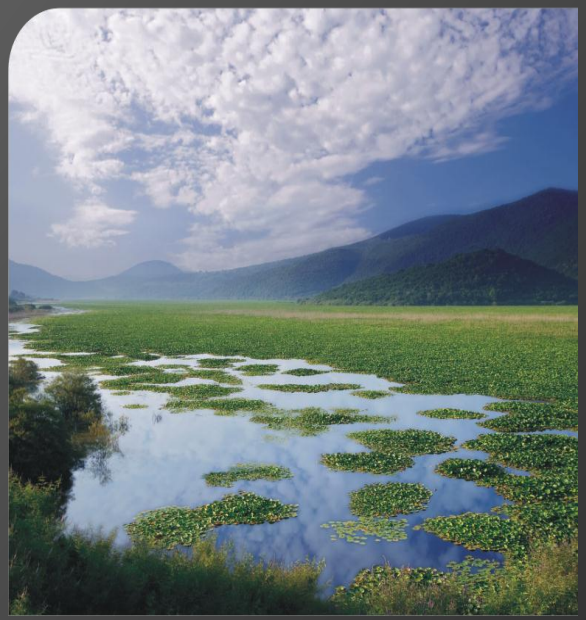


MWFP Conference 2013

Alternatives to Phosphorus Treatment in Food Processing Wastewaters

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and
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December 4, 2013

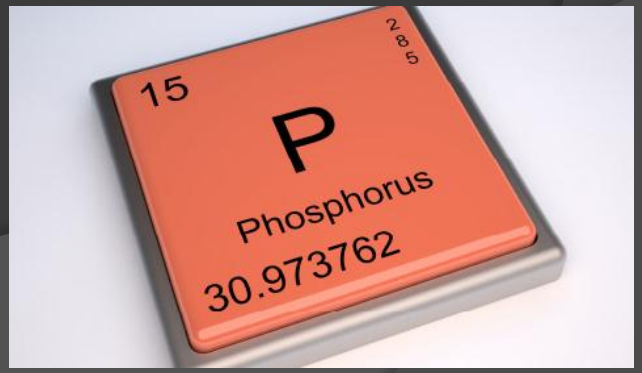
Presentation Outline

- Phosphorus in Food Processing Waters
- Regulations
- Treatment Alternatives
- Case Study: Del Monte Facility in MN

Phosphorus

- Phosphorus an essential nutrient required for proper cell functioning, regulation of calcium, strong bones and teeth, and for making ATP.

- Phosphorus is found in almost every food
  - Dairy Products, Meat, and Fish are high in P
  - Polyphosphate food additives including soft drinks (phosphoric acid)



Top 10 Foods Highest in Phosphorus

#1: Seeds (Pumpkin)

#2: Spices (Ground Mustard Seed)

#3: Cheese (Parmesan)

#4: Nuts (Brazil)

#5: Cocoa Powder

#6: Edamame (Soybeans)

#7: Baker's Yeast

#8: Bacon

#9: Liver (Beef)

#10: Canned Sardines

References

1. *USDA National Nutrient Database for Standard Reference, Release 25.*
2. *Linus Pauling Institute on Phosphorus*
3. *University of Maryland Medical Center Article on Phosphorus*
4. *National Research Council, Food and Nutrition Board. Recommended Dietary Allowances. 10th ed. Washington, D.C.: National Academy Press; 1989:184-187.*

Phosphorus Enters Wastewater

- Cleaning production lines
- Scraping food preparation vats
- Cleaning and rinsing equipment
- Disposing of product to the drain, and
- Floor cleaning chemicals

Key: Identify your sources

Why Do We Care?

- Why is Phosphorus regulated?
- What happens when Phosphorus gets into receiving streams?
- How is Phosphorus regulated?
  - Standard Effluent Limitations
  - TMDL

Phosphorus TMDL

- Phosphorus TMDLs are being developed across the nation.

- Wisconsin tightening Phosphorus TMDL regulations for point source discharges in order to reach 75 - 100 ppb

Treatment Alternatives

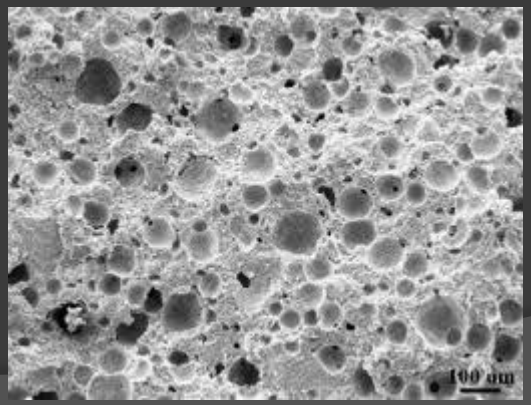
- Reduce Source
  - BMP implementation
- Physical:
  - filtration for particulate phosphorus
  - membrane technologies
- Chemical:
  - precipitation
  - physical-chemical adsorption
- Biological
  - assimilation
  - enhanced biological phosphorus removal (EBPR)

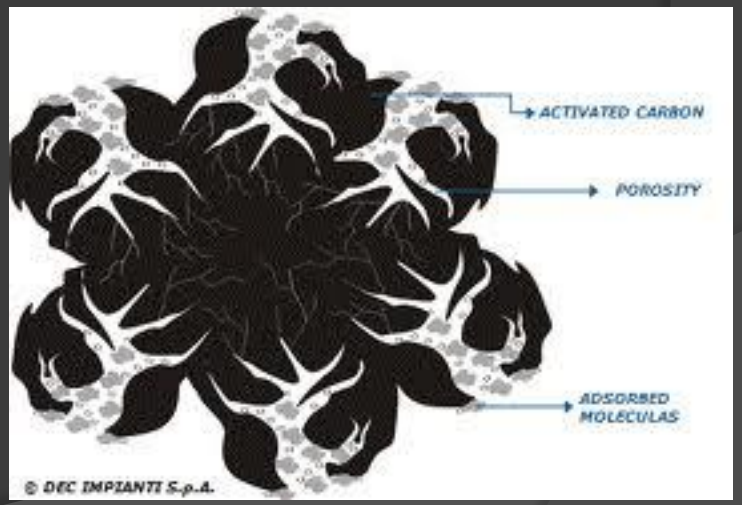
Chemical Precipitation

- Widely used method for phosphorus treatment
  - Chemical Compounds – Calcium, Aluminum and Iron
- Challenges:
  - Chemical costs
  - Solids Management

Physical Chemical Adsorption

- Removes dissolved Phosphorous, not just a physical filtration process
- Media Selection and HRT are critical
- Challenges:
  - Competing Constituents
  - TSS levels





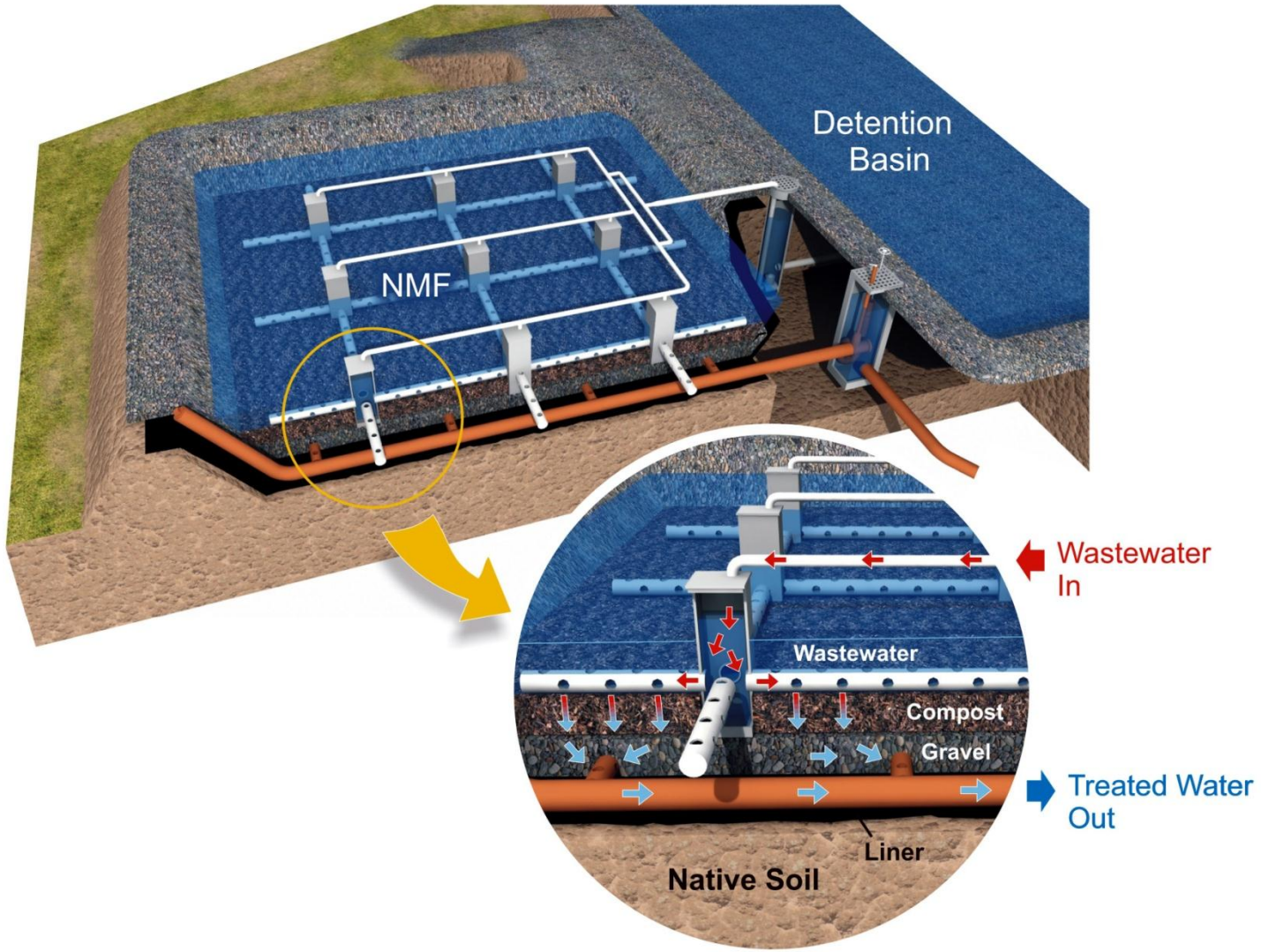
Natural Media Filtration (NMF)

The use of natural materials to filter, adsorb and sequester contaminants from groundwater, process water, and/or stormwater.

- Media Types
  - Compost
  - Sand
  - Gravel
  - Peat
- Removal Mechanisms
  - Filtration
  - Adsorption
  - Ion Exchange
  - Precipitation
  - Decomposition
  - Microbial Metabolism

NMF Schematic

ROUX



NMF in Indiana

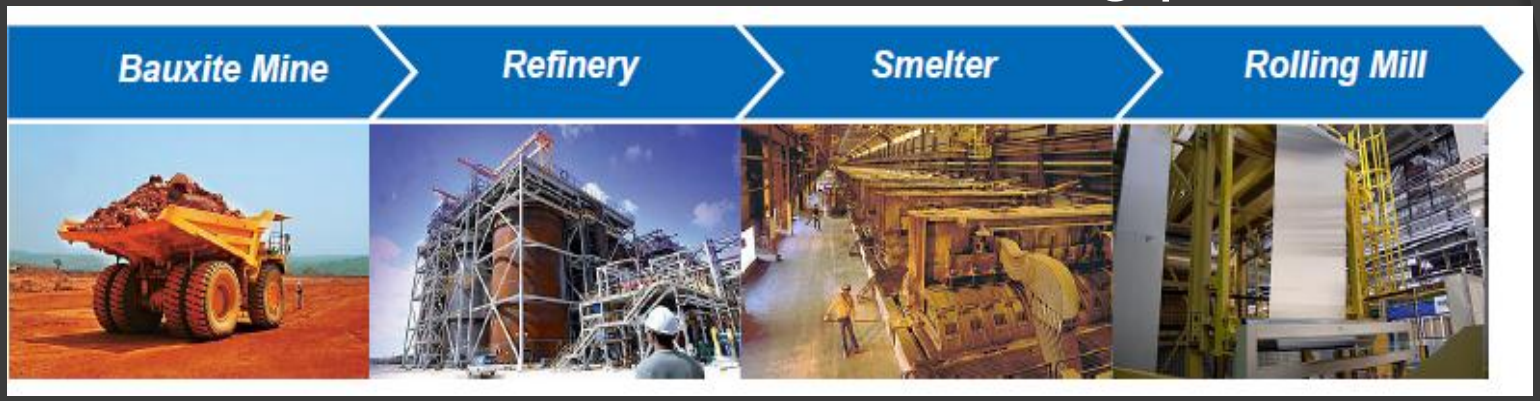
NMF in Virginia

ROUX

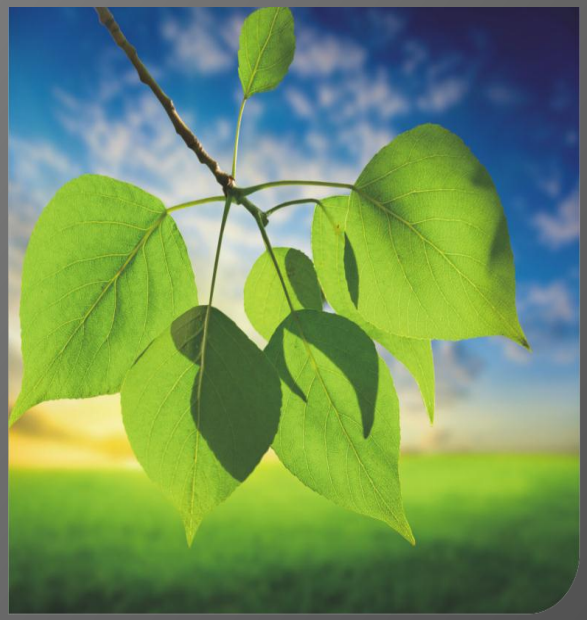
Media Selection

Why Bauxite Residue?

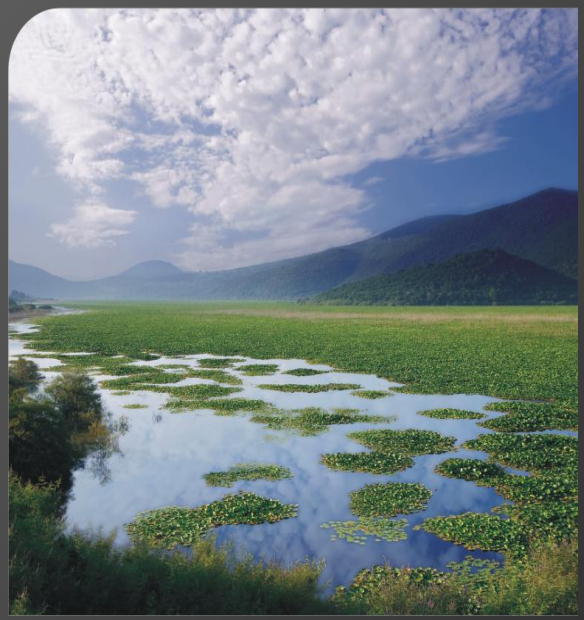
- Red Mud or Bauxite Residue is a solid waste of aluminum manufacturing process



- Patents
- Iron content of Bauxite aids in chemical adsorption







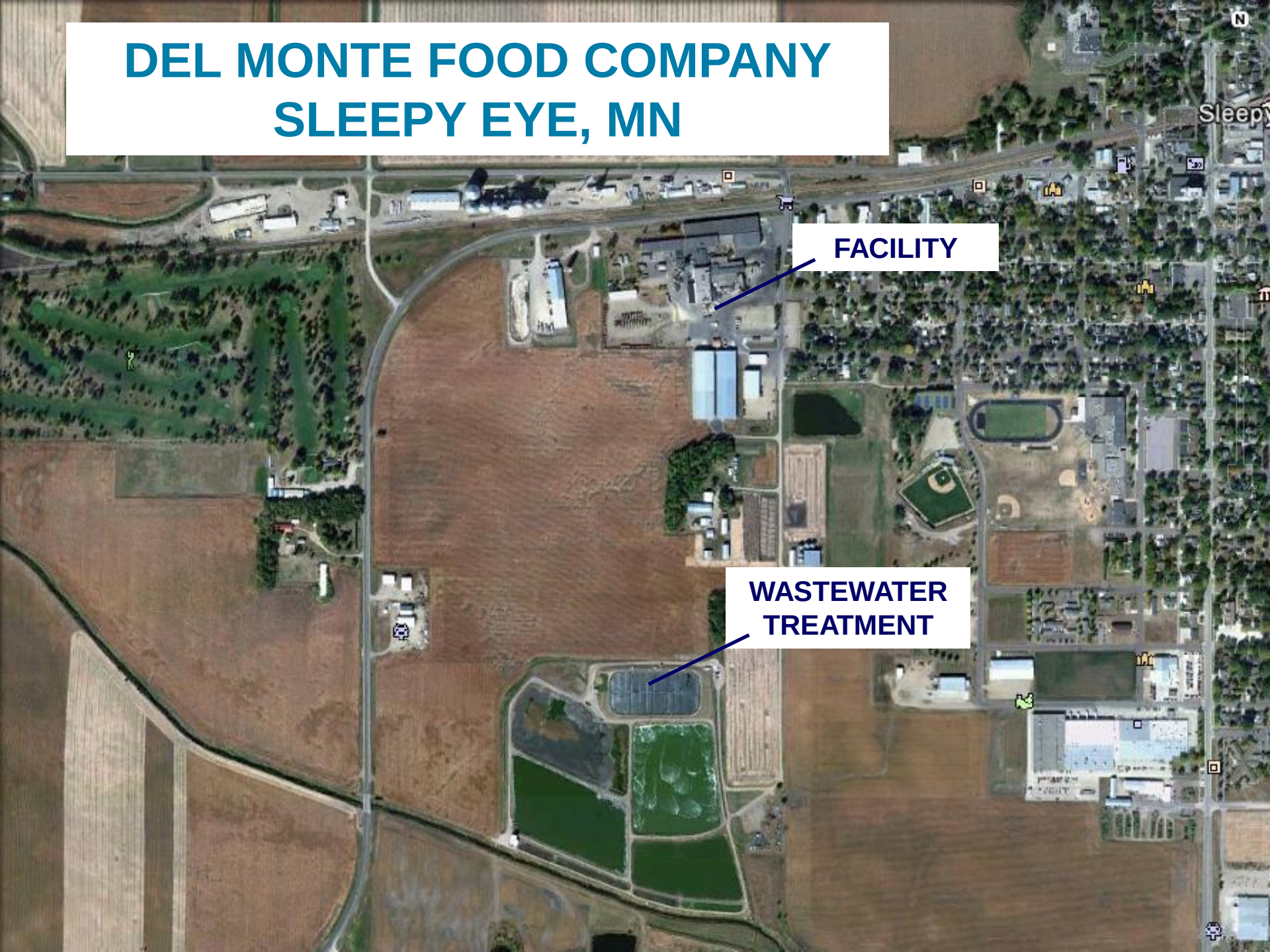

Case Study

NMF Bench Testing
Del Monte Process Water

ROUX

Del Monte Quality

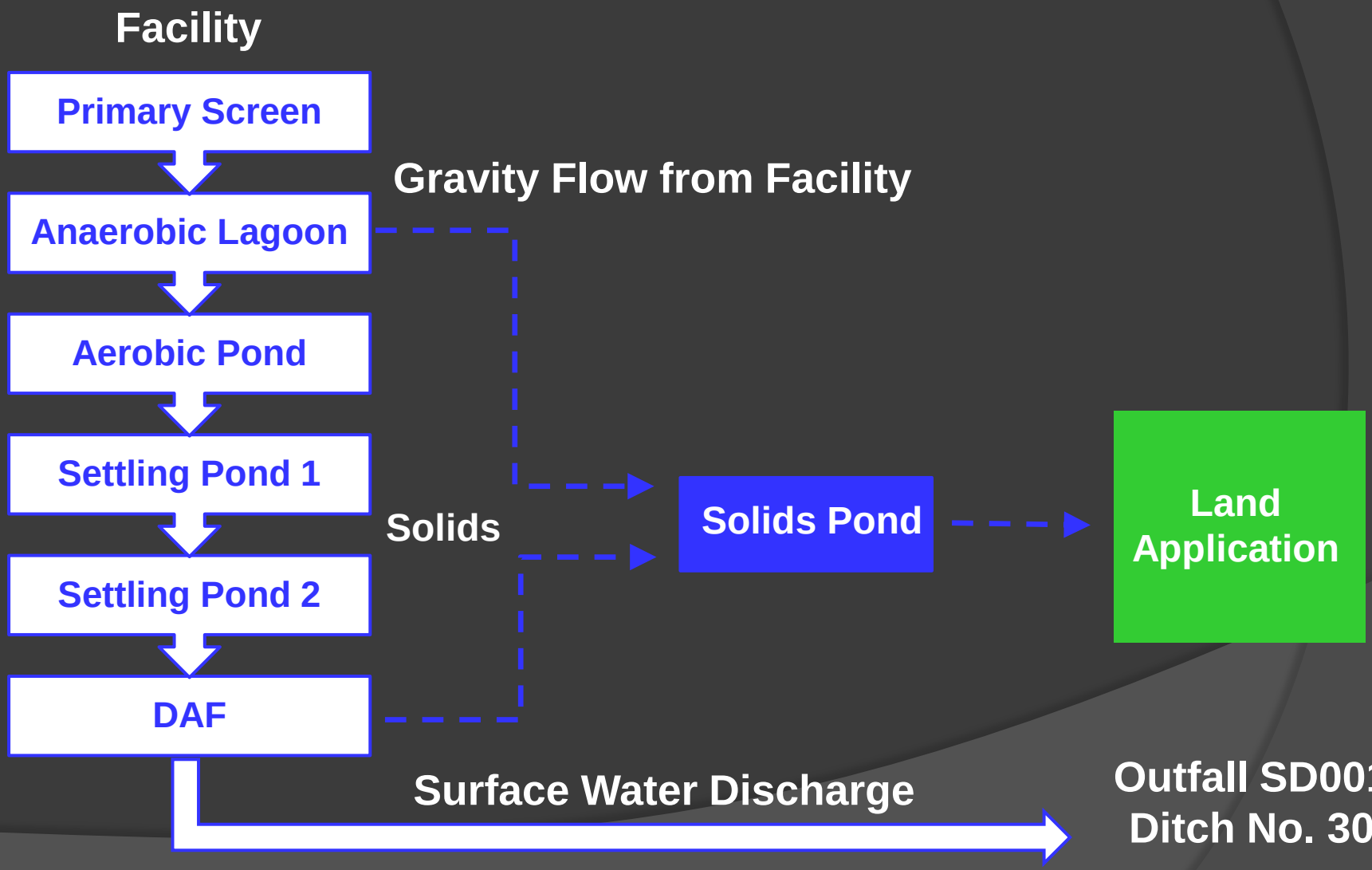
DEL MONTE FOOD COMPANY
SLEEPY EYE, MN



Facility

- Processing and Canning of Peas and Corn
- Seasonal Production - April to November
- High Strength Organic Wastewater
- Process Water Generation
  - Vegetable processing and clean-up water
  - Boiler blow-down and cooling water
  - Non-contact cooling water
  - Storm Water Runoff
- Sanitary wastewater is routed to City of Sleepy Eye WWTF
- Fluctuating Flows
  - Max Daily Flow June to November 250,000 gpd
  - Max Daily Flow April & May 650,000 gpd

Existing Wastewater Treatment Process




Pond 1
Anaerobic Lagoon
4 acres
Solids Pond
7.5 acres
Pond 2
Aerobic Pond
8.3 acres
Pond 4
Settling Basin
8.2 acres
Outfall SD001
To Ditch No. 30
DAF Units (2)
Pond 3
Settling Basin
5.5 acres

Site Challenges

- Algal growth in Settling Ponds 3 and 4
- High TSS levels that are difficult to settle
- Fluctuating flows and concentrations
- Flows routinely recycled and stored to meet discharge limits

Focused Constituents of Concern
NPDES Permit MN0001171

- Nitrogen, Ammonia
  - 19.4 mg/L (Apr-May), 6.4 mg/L (Jun-Sep), 32.5 mg/L (Oct-Nov)
- BOD
  - 25.0 mg/L (Apr-May), 15 mg/L (Jun-Nov) – monthly ave
  - 37.5 mg/L (Apr-May), 22.5 mg/L (Jun-Nov) – daily max
- Total Suspended Solids (TSS)
  - 45 mg/L month ave, 67.5 daily max
- Phosphorus
  - Mass limit – 5 month 967 kg

Minnesota Pollution Control Agency

Project Objectives

Phosphorus Treatment

- Reduction of chemical use / elimination of DAF units for colloidal particle and phosphorous control
- Final Discharge: Meet NPDES discharge limits BOD, Ammonia, TSS, Phosphorous

Proof of Technology: Pilots

Bench Scale

Small Field

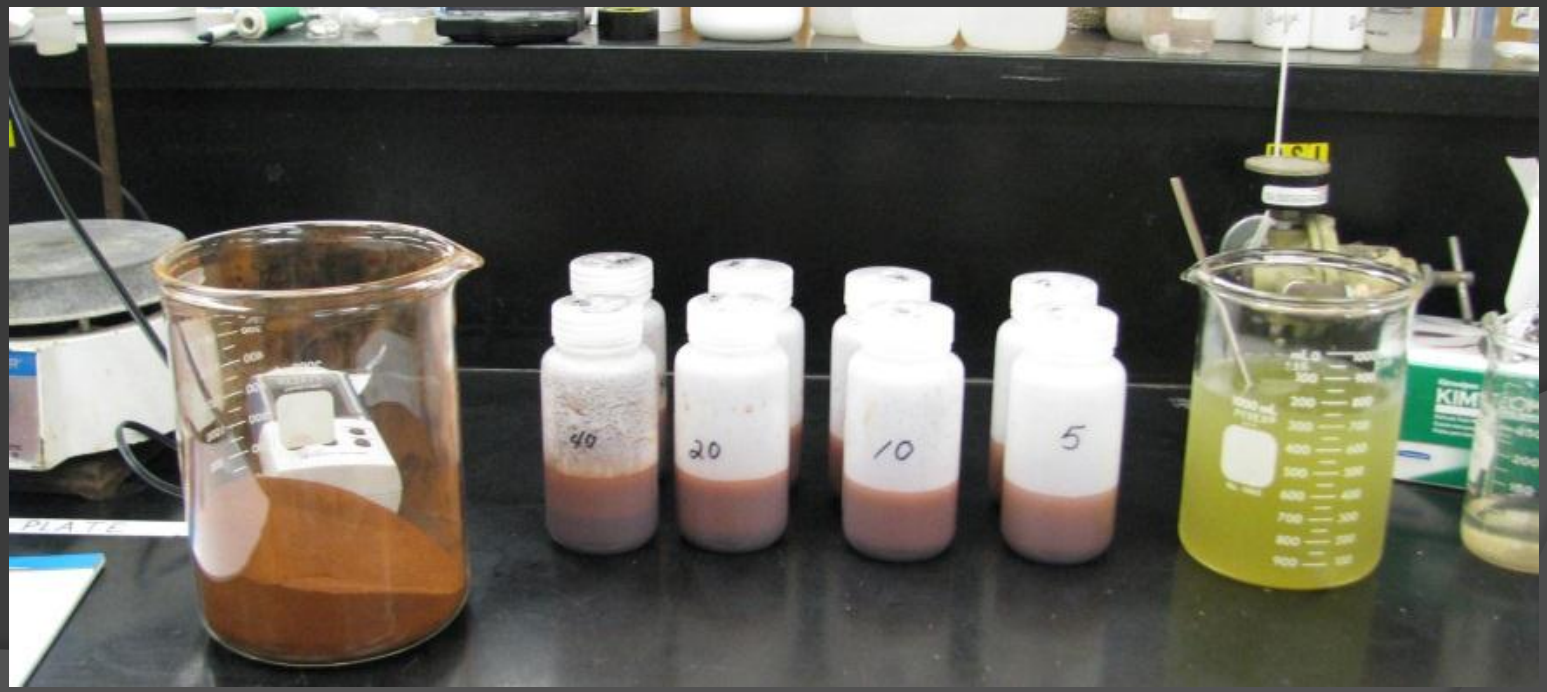
Large Field

Bench Scale Pilot Study

- Step 1: Complete water quality analysis
  - Identify any competing constituents
- Step 2: Batch Study
  - Isotherm Adsorption Capacity / Rate of Reaction
- Step 3: Column Study
  - Evaluate longevity of media
- Step 4: Application - System Sizing

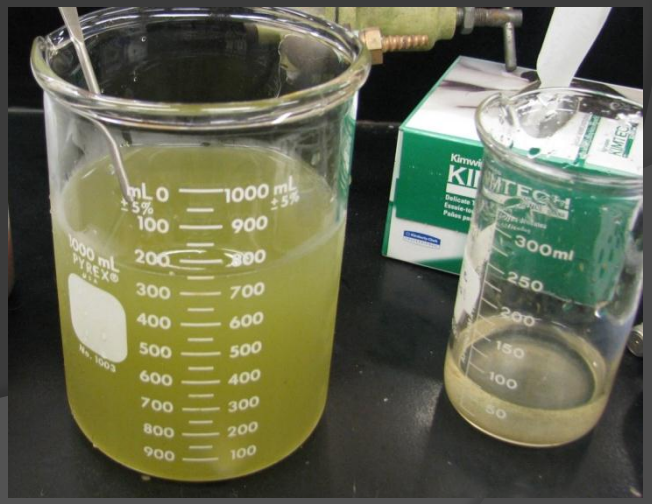
Bauxite Batch Isotherm Study

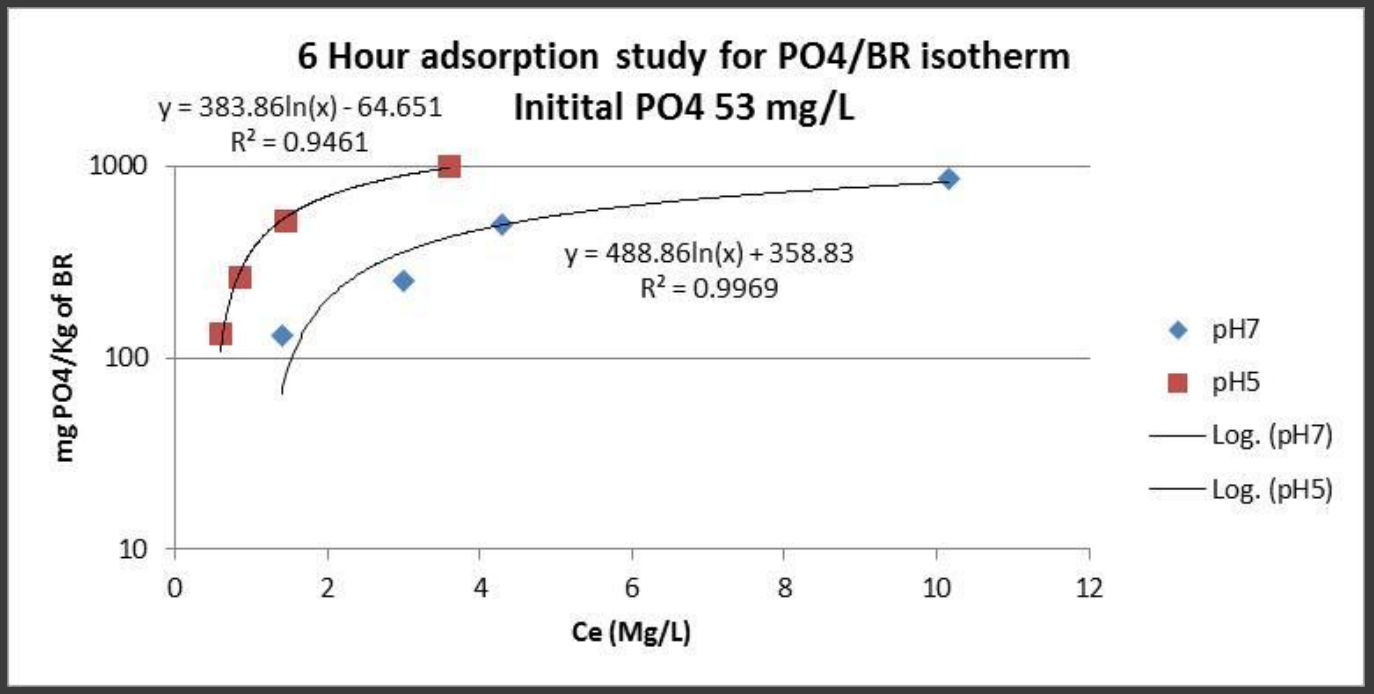
- 5 batch tests in duplicate
- Water volume constant, Bauxite volume varied
- Neutral and Acidic pH ranges tested
- 2 hr., 4 hr., 6 hr. and 24 hr. HRT evaluated

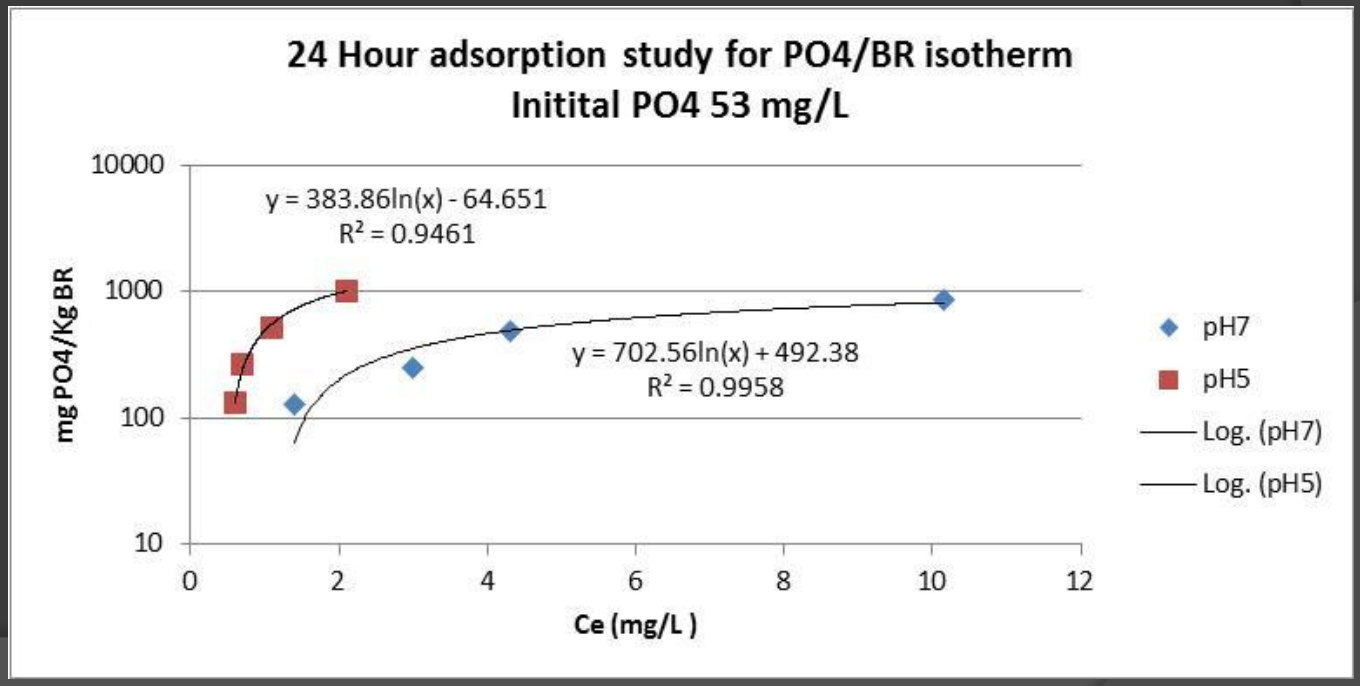


Study Results

- Successful Phosphorus removal
  - Initial: Total PO4 = 78 mg/L
  - After Filtration: PO4 = 53 mg/L
  - Max removal: 99% reduction to 0.6 to 1.4 mg/L
- HRT 4 hours to reach equilibrium
- Adjusted pH of solution increased Phosphorus removal

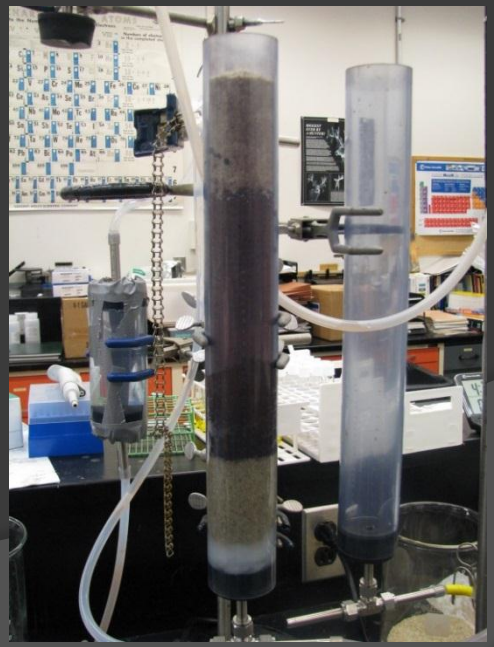



6 Hour adsorption study for PO4/BR isotherm
Initital PO4 53 mg/L
y = 383.86ln(x) - 64.651
R² = 0.9461
y = 488.86ln(x) + 358.83
R² = 0.9969
mg PO4/Kg of BR
1000
100
10
0
2
4
6
8
10
12
Ce (Mg/L)
pH7
pH5
Log. (pH7)
Log. (pH5)


24 Hour adsorption study for PO4/BR isotherm
Initital PO4 53 mg/L
y = 383.86ln(x) - 64.651
R² = 0.9461
y = 702.56ln(x) + 492.38
R² = 0.9958
mg PO4/Kg BR
10000
1000
100
10
0
2
4
6
8
10
12
Ce (mg/L)
pH7
pH5
Log. (pH7)
Log. (pH5)

Additional Bench Testing

- 2 Stage Column Study
  - 2 and 6 inch diameter column, 24 inches high
  - Flow rate between 2.0 and 10 mL/min
  - Test Length ~ 10 days



Field Pilot

- Considerations:
  - TSS & BOD removal before NMF
  - Integration of NMF into existing system


Potential Areas
for Field Pilot

Bauxite Field Pilot System and Full Scale System Sizing and Costs

- Bauxite Field Pilot System treating up to 5,000 gpd installed < $75,000

- Full Scale System treating up to 250,000 gpd installed ~ $400,000 - $600,000

Conclusions

- Phosphorus treatment is important, regulations are becoming more stringent
- Source identification is essential
- Economical treatment alternatives do exist to meet discharge requirements
  - Natural Media Filtration

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