



**WISCONSIN
WASTEWATER
OPERATORS'
ASSOCIATION**

**ANNUAL CONFERENCE
GREEN BAY**

**MEETING LOW LEVEL
PHOSPHORUS LIMITS BY
CHEMICAL ADDITION**

WHAT IS PHOSPHORUS

- Atomic # 15
- Electron Configuration – Ne 3s² 3p³
- Compounds
 - Phosphorus (V)
 - Oxides
 - Nitrides
 - Sulfides
 - Phosphorus (III)
 - Organophosphorus



Bad Beards







QUESTIONS

- CAN I MEET MY DISCHARGE REQUIREMENTS WITH JUST CHEMISTRY?
- IS IT GOING TO BE COST COMPETITIVE?
- IS IT SOMETHING THAT I CAN OPERATE?
- HOW CAN I HANDLE THE SOLIDS?
- DO I NEED FILTRATION?



Lowering “P” Via Chemical Additions and Downstream Effects

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Current and New Technology

- Current Treatment Options
 - Iron Based
 - Alum Based
- New Treatment Options
 - Other forms of Aluminum (ACH, PACL)
 - Blends including Organic Polymers
 - Rare Earth Metals

Chemical P Removal

- **Not Technically Precipitation**
 - **FePO_4 and AlPO_4 only exist at very low pH (less than 5)**
 - **Fe or Al + along with Alkalinity form Hydrrous Metal Oxides in Wastewater**
- **Absorption of soluble (PO_4^{3-}) phosphate into metal hydroxide floc.**
- **As Floc is formed and falls it also entraps particulate “P”**

TYPICAL CHEMICALS

- **Aluminum Based**
 - Aluminum Sulfate (Alum)– 8% Al
 - PolyAluminum Chloride (PAC) – 5-20% Al
 - Aluminum Chlorohydrate (ACH) – 10-24%
- **Iron Based**
 - Ferric and Ferrous Chloride and Sulfate
- **Additives**
 - Diallyldimethylammonium Chloride – DADMAC or Poly DADMAC
 - Poly Amines – EPI
 - Iron, Calcium, Sulfur Enhancement

Goals of the Chemical Addition

Optional Treatment Points

Downstream Requirements

**Water Quality of Samples (pH,
Alkalinity, TSS, etc)**

Optional Treatment Points

- Plant Headworks – Usually with Ferric Products
 - Helps controls Odors, Increased Contact Time
- Bioreactor and or Clarifier
 - Improves Removal of P, TSS, BOD (Colloidal Removal) beware or removing too many nutrients
- Tertiary Clarifier
 - High degree of flexibility
- Tertiary Filtration
 - Filtration Design depends on settling needed
- Anaerobic Digester
 - Usually Iron – Reduces H₂S gas levels
- Dewatering
 - Can change Dewatering Characteristics – Different Cationic Polymers may be needed – Different Charge, Different Structure – High Levels can be found in Effluent Water from Dewatering Applications

Single feed point or multiple feed points

JAR TESTING

- Need representative sample
- Determine Optimum Feed Point or Points and Mixing Speed and Retention Times
- Mimic Plant Conditions and Determine Best Product at the Proper Dosage to Meet and Exceed Plant Requirements
- Determine Optimum Feed System including pumps, storage tanks, and feed strategy
- **Theoretical or Stoichiometric Approximations are not useful when working with low P concentrations**

4.3 MGD BIOLOGICAL REMOVAL PLANT

- Influent Phosphorus Level – 7.3 ppm as P
- Goal was 1 ppm but wanted to determine lowest possible effluent concentration
- Biological Nutrient Removal resulted in 0.75 ppm on average but spikes were seen above 4.0 ppm and low removal rates were seen in winter
- Ferric Chloride was used to lower P to 0.32 ppm
- Supplemental Nutrients were added to boost biological removal
- An ACH blend after biological removal lowered rates to less than 0.03 ppm as P

250K GPD Western Wisconsin RBC

- Influent Phosphorus Level – 2.71 as P
- Goal was 1 ppm but scheduled to be reduced to 0.3 ppm
- Ferric Chloride 35% at 40 ppm lowered dosage to 0.26 ppm as P
- **Chemical Usage increased to 7.5 gpd**

95K GPD Southern Wisconsin

- Influent Phosphorus Level – 1.63 as P
- Target Discharge Level was 0.04 ppm as P
- **220 ppm of Ferric plus 5 ppm of Poly Amine allowed to reduce P levels to 0.023 ppm**

200K GPD Central Wisconsin SBR

- Influent Phosphorus Level – 5.34 as P
- Less than 0.1 ppm as P for discharge
- Ferric Chloride 35% at 50 ppm lowered dosage to 0.6 ppm as P
- **PACL at 100 ppm and 0.5 ppm of Cationic Polymer provided P levels of 0.06 ppm**

15.6 Acre Lagoon System in Northern MN

- Influent Phosphorus Level – 4.43 as P
- Discharge Limit – 1.0 ppm
- **Alum Dosage of 180 ppm reduced P levels to 0.66 ppm and 100 ppm of PACL Blend reduced P levels to 0.09 ppm.**
- Fed via Pontoon Boat in motor vortex

DOWNSTREAM EFFECTS

pH

- Alum or Iron Salts will decrease pH, especially at higher dosages
- ACH will lower pH slightly
- PAC will not lower pH

TOTAL SUSPENDED SOLIDS

- 1 mg/L Iron Dosage = 1.9 mg/L TSS
- 1 mg/L Aluminum Dosage = 2.8 mg/l TSS
- Dosage Optimization and settling will yield lower TSS
- However, Settling can be problematic and in some cases we add Cationic Polymers to aid in settling time when filtration is not used. Need to be careful on addition point and possibly need additional feed equipment.
- Loading on Filters can be increased if settling is not optimized. In most cases, loading can be reduced due to better settling and TSS removal

FILTER PERFORMANCE (If Equipped)

- An overdose of products can cause rapid head loss or binding of material
- Increase loading on plants not equipped with proper settling which causes additional backwashes and or water and energy usage

DEWATERING CHARACTERISTICS

- Changes to Chemical type can lead to changes in Cationic Polymers for Dewatering
- Higher percent solids in sludge going to dewatering
- Higher amounts of sludge due to higher dosages or if using an ACH or PAC, lower amount of sludge due to decreased dosage
- Various products can increase or decrease the mobility of P in land applied solids

Other Effects

- Reduction in Struvite Formation
- Reduction of Odors and Corrosion caused by Hydrogen Sulfide when using Iron Products
- BOD Removal
- Precipitation of other metal species – Good for effluent discharge / bad for land application

Advantages

- Can be used in every single current wastewater application from Lagoons to EBPR (Enhanced Biological Phosphorous Removal).
- Easy Plant Trials – Chemical and Feed Pump are the only requirements
- Low Capital Costs
- Easy to adjust to changing influent concentrations and flows
- Relatively Easy to Model in Laboratory/ Plant
- Less Complicated Method of Removal

Disadvantages

- Operation and Maintenance Costs can be higher due to chemical usage
- Handling and Storage of different chemicals and freeze protection
- Iron Products are not recommended in front of UV disinfection due to staining
- Can Reduce pH if using a low pH product
- If fed at wrong area, it can reduce nutrient levels to beneficial bugs and cause die off.
- Possible changes to dewatering chemistries
- Increased Sludge Production depending on products



Questions?

- Please feel free to ask any questions regarding this information or any other concerns you have
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