CDM

Options for controlling phosphorus from wastewater treatment plants

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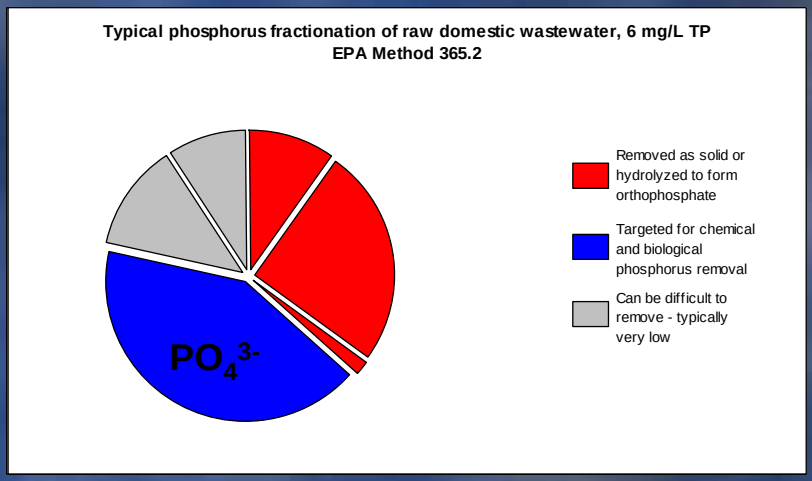
Outline

- Forms of phosphorus
- Typical suspended growth system
- Phosphorus removal - approach
  - Biological phosphorus removal
  - Chemical phosphorus removal
  - Tertiary chemical processes
- Achievable NPDES permit limits for TP
- Advantages/disadvantages
- Indirect environmental impact

Forms of Phosphorus

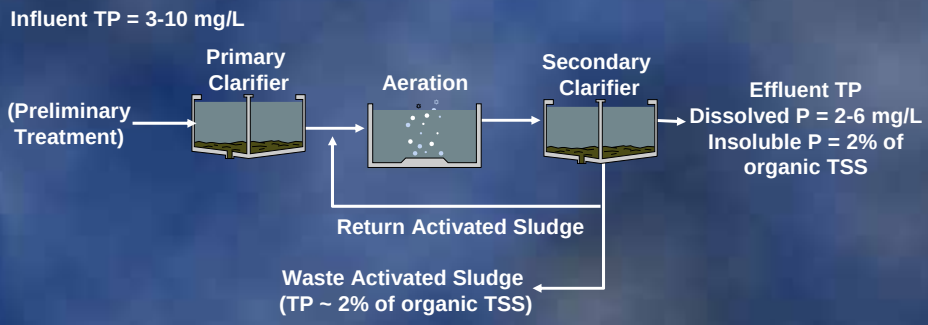


Source: Maurer, M. & Boller, M. 1999. Modelling of phosphorus precipitation in wastewater treatment plants with enhanced biological phosphorus removal. Water Science and Technology 39:1, 147-163.

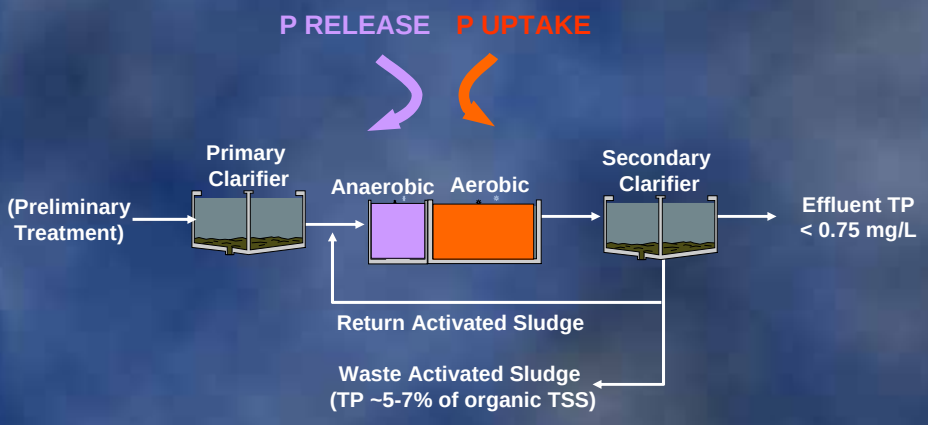
Phosphorus removal - approach

- Convert orthophosphate to a solid, then remove the solid
- Types of solids
  - Biological (microorganisms)
  - Chemical (precipitates)
- Types of removal
  - Gravitational settling
  - Floatation
  - Filtration
  - Membranes

Typical suspended growth system



Biological phosphorus removal

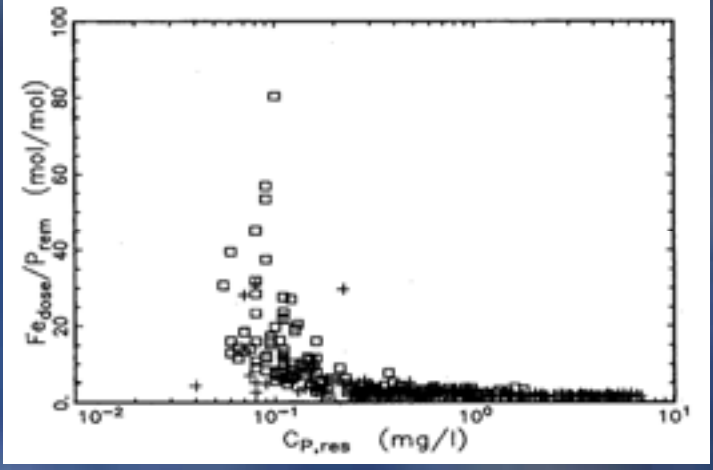


Aerobic = with oxygen
Anaerobic = no oxygen, no nitrate

Chemical phosphorus removal

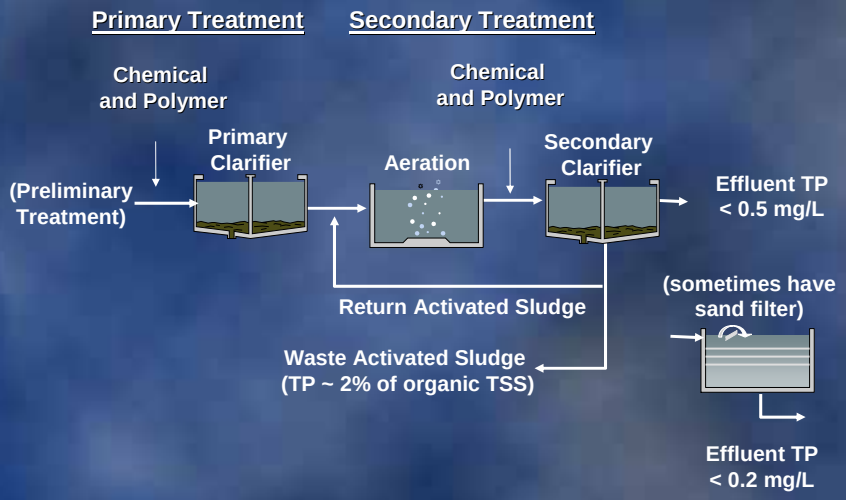
- Add chemical coagulants/precipitants
  - Aluminum salts
  - Iron salts
  - Calcium compounds
- Add polymers
- Enhance settling by
  - Precipitating orthophosphate
  - Coagulating particulates of all kinds

Chemical phosphorus removal



Smaller gains with increasing dose

Chemical addition points



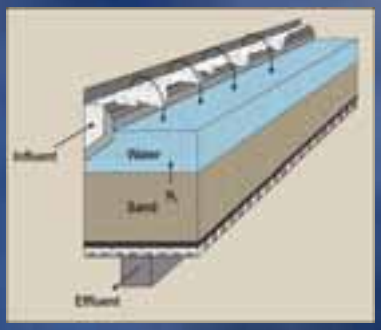
Tertiary chemical processes

- Secondary effluent of either
  - Biological phosphorus removal
  - Chemical phosphorus removal
- All require (more) chemical addition
- Lower TSS = lower effluent phosphorus
- Advanced solids removal:
  - Tertiary filtration
  - High rate clarification
  - Dissolved air floatation
  - Solids contact
  - Membranes

Tertiary filtration

Traveling bridge sand filters

- Flows through
- Solids retained on bed
- Cleaned by backwashing
- Reliably achieve <0.2 mg/L



Disc filters

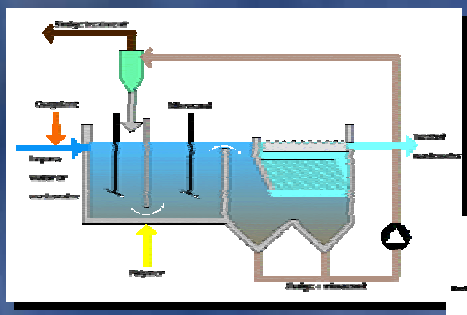
- Three approved for reuse
- Flows 'outside in' or 'inside-out'
- Cleaned by backwashing
- Reliably achieve <0.1 mg/L

Tertiary filtration – cont'd

Continuous-backwash filters

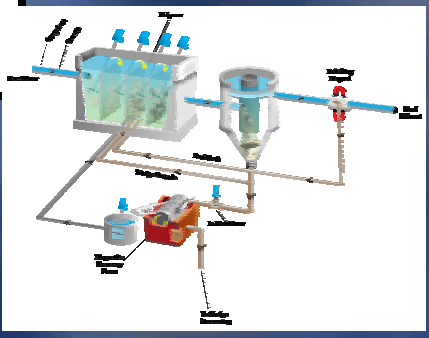
- Parkson DynaSand
- Blue Water Technology BluePRO
  - Orthophosphate adsorption process
- Flow is up through the bed, continuous operation
- Can be used in series for improved performance
- Reliably achieve <0.1 mg/L TP

Ballasted flocculation



Kruger – ACTIFLO

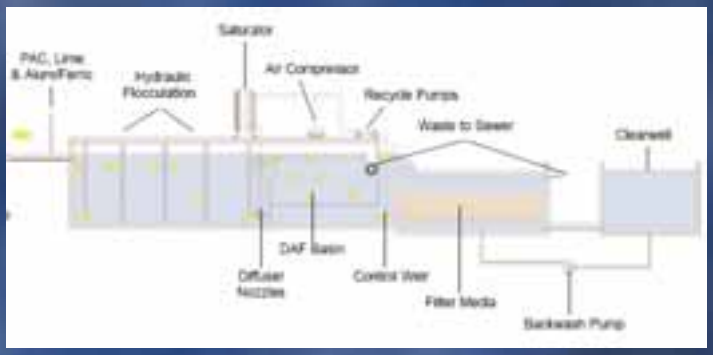
- Microsand ballast
- Hydrocyclone sand recovery
- Lamella plate settlers
- Reliably achieve <0.1 mg/L



Cambridge Water Technology – CoMag

- Magnetite ballast
- Magnetic recovery drum
- Polishing magnet
- Reliably achieve <0.1 mg/L

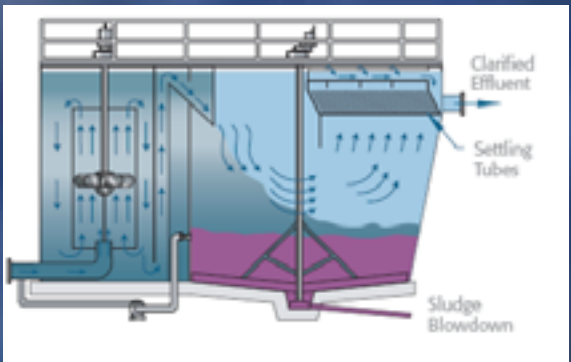
Dissolved air floatation



Degremont AquaDAF

- Dissolves air under pressure
- Air bubbles form when released, trapped in solids
- Solids float to surface for removal
- Reliably achieve <0.1 mg/L

Solids contact

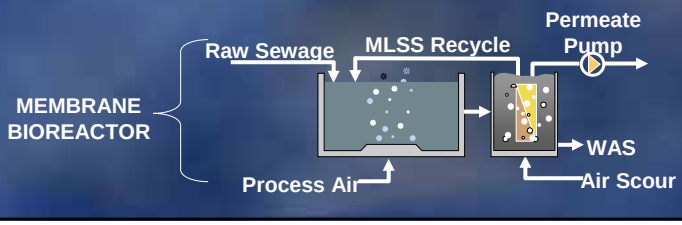


Degremont Densadeg

- Uses existing solids as 'seed' for greater floc formation
- Achieves more efficient solids capture with plate settlers
- Reliably achieve <0.2 mg/L

Membranes

- Small, hollow, porous fibers (most common, shown)
- Also as plates (not shown)
- Under vacuum –clean water is pumped through
- Can be used for solids removal or as a membrane bioreactor
- Reliably achieve <0.05 mg/L



Achievable NPDES TP permit limits

- Secondary systems w/o filtration
  - Biological removal — 0.75 mg/L
  - Chemical removal — 0.50 mg/L
- Secondary systems w sand filtration — 0.20 mg/L
- Tertiary chemical processes
  - Ballasted flocculation — 0.10 mg/L
  - Tertiary filtration — 0.10 mg/L
  - Dissolved air floatation — 0.20 mg/L
  - Solids contact — 0.10 mg/L
  - Membranes — 0.05 mg/L

Depends on the concentration of the dissolved, non-reactive fractions – can be as high as 0.02 – 0.5 mg/L in rare cases

Advantages

- Biological phosphorus removal
  - Lower operating cost
  - Less sludge production
  - Easier to operate
  - Safer
- Chemical phosphorus removal
  - More reliable
  - Lower concentrations possible
  - Smaller footprint
- Tertiary chemical phosphorus removal
  - Even lower concentrations possible

Disadvantages

- Biological phosphorus removal
  - Potential for phosphorus release from sludge
  - Larger footprint
  - Less reliable
  - Dependent on certain carbon sources (VFAs)
- Chemical phosphorus removal
  - High sludge production
  - High operating costs (chemical use)
- Tertiary chemical processes
  - High capital costs
  - High operating cost (chemical use, power consumption)

Indirect environmental impacts – achieving low limits with chemicals

- Operation and Maintenance
  - Chemicals
  - Power
  - Labor
- Sludge Quality and Quantity
  - Dewaterability
  - Increase in sludge production
  - Disposal
- Truck Traffic
  - Chemical
  - Sludge

For questions or for a copy of this presentation

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Bioavailability of recalcitrant fractions

- dissolved acid hydrolyzable and organic phosphorus
  - 22% for domestic effluents
  - 21-46% for commercial effluents
- insoluble phosphorus
  - 25% for domestic effluents
  - 13-46% for commercial effluents
- Orthophosphate
  - Near complete for all effluents

Ekholm, P. & Krogerus, K. (2003). Determining algal-available phosphorus of differing origin: routine phosphorus analysis versus algal assays. Hydrobiologia. 492:29-42.