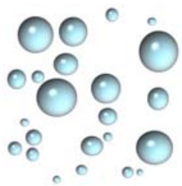
Package Treatment Plant Operation and Management

Treatment Processes: Part 2



Joe Whitehead

Introduction

In this session we will cover:

Common PTP Treatment Processes

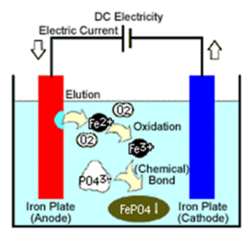
- Phosphorus Removal
- Odour Management
- Disinfection Processes
- Solids Handling / Management

Chemical Phosphorus Removal

- Principal method of P removal by chemical precipitation
- Addition of salts of multivalent ions that form precipitates of sparingly soluble phosphates
- Ca^{2+}, Al^{3+} and Fe^{3+} can be used
- If lime is added pH will rise and precipitate phosphate, but subsequent pH adjustment is required
- Ferric chloride is most commonly used to precipitate phosphate
- Increases sludge load
- Required dosing usually determined by bench test

Electrolytic Phosphorus Removal

- Some systems may include 'sacrificial anode' for electrolytic Phosphorus removal
- c.f. former FujiClean CRX Domestic Model



Fuji Clean Australia Pty Ltd

Odour Control

Various methods of odour control:

- Physical
- Chemical
- Biological

Physical Odour Control

- Adsorption on activated carbon, use of AC cartridges or filters
- Containment (seals and hoods)
- Dilution with air, discharge through vent stacks
- Thermal oxidation, but generally requires high temperatures, so is not commonly used

Chemical Odour Control

- Caustic scrubbing in scrubbing tower
- Recirculating through packed bed scrubbers containing chemical oxidants:
  - Sodium hypochlorite
  - Chlorine solution
  - Hydrogen peroxide
  - Potassium permanganate
- Dosing and settling
  - Magnesium hydroxide (Milk of Magnesia)

Biological Odour Control

- Biological conversion by oxidation
- Biological scrubbing in a tower filled with bulk media for attached growth
- Compost beds
- Sand and soil beds
- Above two options are simple and cheap, low technology alternatives
- Passing odorous gasses back through trickling filters or activated sludge tank through aeration diffusers

Disinfection

- Disinfection destroys pathogenic microorganisms in the wastewater stream
- Differs from sterilisation which aims to destroy all organisms
- Disinfection processes range from boiling to large-scale chemical treatment
- Methods encountered may include:
  - Chlorination – most common
  - Ultraviolet irradiation (UV) – gaining acceptance
  - Ozonation – remains specialised
- Each has limitations and advantages

Chlorination

- Most commonly encountered and understood disinfection method
- Can be delivered in gaseous (hypochlorite), liquid or salt (hypochlorous) form
- Chlorine is strongly oxidising, highly penetrative and toxic to microorganisms
- Readily available with moderate to high handling and safety requirements
- Effective disinfection process for most pathogens
- Provides residual protection (can be measured)
- Must consider LAA and by-product formation

Chlorination

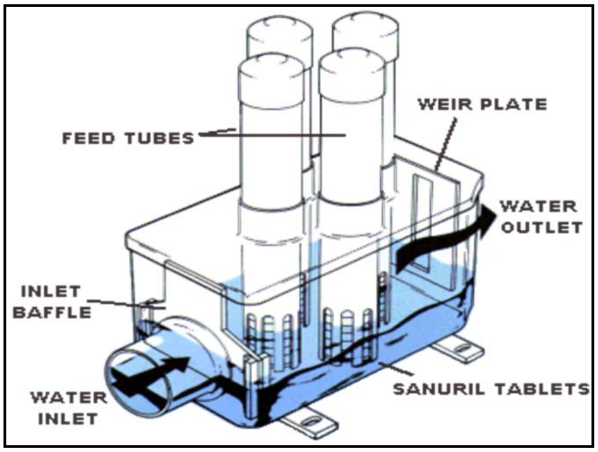
Critical Factors:

- Typically requires turbidity <5 NTU
- A neutral pH is desirable
- Even small amounts of BOD_5 will quickly consume chlorine through oxidation
- Total Suspended Solids (TSS) will shield organisms and exert a chlorine demand

Chlorination

Critical Factors (continued):

- Unoxidised Ammonia (NH_3) will consume chlorine
- Microbial clumping may limit effectiveness
- High organic loads may lead to the production of harmful organochlorine compounds
- Excess chlorine residual will kill the good microbes in the soil (LAA)



Sodium hypochlorite dosing unit and contact tank

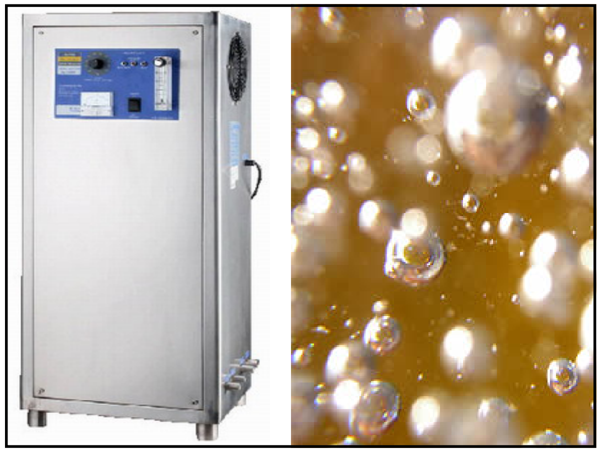
Ozonation

- Uses ozone (O_3) to inactivate pathogenic microorganisms by cell wall destruction and nucleic acid damage
- Ozone is strongly oxidising, highly penetrative and toxic to microorganisms
- Readily available with moderate to high handling and safety requirements
- Ozone must be generated onsite from oxygen gas
- Highly effective for all pathogens
- Provides no residual protection

Ozonation

Critical Factors:

- Production limited by oxygen gas concentration and impurities
- Breakdown of ozone to oxygen is rapid – requiring highly effective contact and dispersal
- High operation and maintenance requirements to ensure effective ozone production maintained
- Relatively expensive for smaller systems



Ozone / Chlorine Control

- Managing delivery and efficacy of chemical disinfection agents difficult
- Time or Demand delivery?
- Can result in wide range of performance
- Use of automated control recommended:
  - Oxidation-reduction potential (ORP) or 'redox' probe connected to metered delivery system
  - Detects changes in the electron status of the solution and reports as a change in oxidation potential (mV)
  - High level of confidence if system calibrated correctly

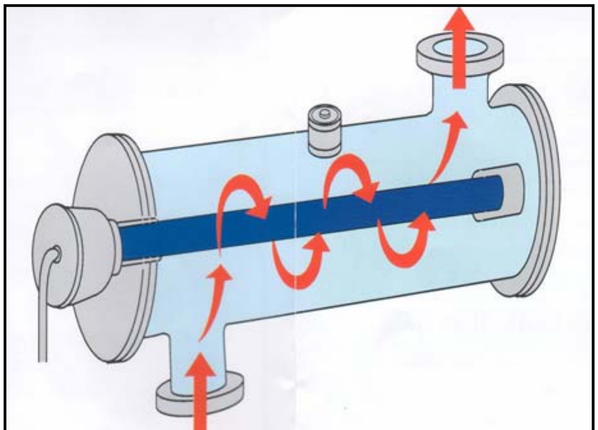
Ultraviolet (UV) Irradiation

- Uses UV (short wavelength) light to deactivate pathogenic microorganisms
- Destroys genetic material (DNA, RNA) and prevents cell reproduction
- UV is moderately penetrative and highly toxic to microorganisms
- Equipment readily available with no incidental handling or safety requirements
- Typically involves passing clarified wastewater through a pipe or tube with adjacent UV tubes
- Provides no residual protection

Ultraviolet (UV) Irradiation

Critical Factors:

- Typically requires turbidity <1 NTU
- Carryover of biological flocs may reduce the effectiveness by shielding pathogens
- Effectiveness is related to contact time, so disinfection process is related to flow through rate
- Balancing/Storage is important
- High maintenance requirements as tube or pipe must be kept clean for optimum performance (some self-cleaning)
- Redundant system is advisable


Source: Onsite Consortium 2004

Solids Management

- Processes described previously all produce waste solids (grit, screenings, scum, solids and biological material) commonly referred as sludge
- Residual solids can be treated in a number of ways:
  - Wasted (as **sludge**) to an STP or other approved location;
  - De-watered to produce biologically active **cake**; or
  - Stabilised to produce **biosolids** for beneficial reuse (soil conditioning etc.)

Solids Management (Sludge)

- The quantity and quality of sludge produced depends on the treatment system and processes used. In general:
  - High Rate (BOD only) treatment plants produce large volumes of sludge and require significant additional downstream treatment
  - Low Rate (BOD/nitrification) treatment plants produce a lesser volume of more stable sludge that is wasted off-site periodically
  - Extended Aeration treatment plants produce minimal sludge that is very stable and relatively inert

Solids Management (Sludge)

- Sludge remains biologically active and must be treated as potentially pathogenic
- Also contains much of the “offensive” constituents of wastewater (odours, pathogens, vectors etc.)
- High water content (>90%) makes volume management and handling problematic
- Typically pumped/transferred off-site as required or stored short-term before transferring
- Must be maintained aerobic to prevent nuisance

Solids Management (Cake)

- In some instances sludge is dewatered to produce cake
- Larger land area or plant requirements, so may not be viable for many situations
- Cake produced by:
  - Air-drying sludge on specially designed (media) beds, or
  - Thickening using specialised plant such as rotary-drum, rotary fan or gravity-belt press thickeners
- Typical water content 25-60% by volume

Solids Management (Cake)

- Dewatering effluent remains active and must be treated and managed accordingly
- Typically returned to the PTP for further processing
- Internal loading must be accounted for in treatment system sizing and design
- Dewatered solids (cake) may be disposed to land (with approval) or other certified solid waste facility

Solids Management (Biosolids)

- Enhanced stabilisation techniques can be employed to produce biosolids for reuse
- Typically associated with municipal facilities and larger commercial operations
- Stabilisation may include:
  - Alkaline stabilisation
  - Aerobic digestion
  - Anaerobic digestion (may include co-generation)
  - Composting