# Bacteria Issues at Wastewater Plants

## Influent Issues

- Influent Strength (multi-family units, offices, and homes/offices with water savings devices produce a higher strength wastewater)
- Industrial Users, Car washes, Restaurants can produce high strength, toxic, or problematic wastewater
- Influent Toxicity
- Degree of Inflow/Infiltration

## Solutions to Influent Issues

- Monitor influent
- Monitor users
- Assure ordinance is appropriate and enforce ordinance
- Charge inspection fees and fine non-compliant users
- Repair I/I

## Lift Station Issues

- Lift Pump size – designed to pump peak flow (usually 4Q) with one unit out of service
- Lift pump control settings may need to be adjusted
- Multiple lift stations in collection system and how they discharge to the plant

## Solutions to Lift Pump Issues

- Repair collection system
- Reduce impeller size, choke back valves on lift pumps, install variable frequency drives to better control flow rate
- Adjust pump settings
- Install a jockey or smaller pump if needed for small flows
- Assure all pumps don't come on at once if not needed

## Solids Loss

- MLSS too high in aeration basin
- Dissolved Oxygen level too low in the aeration basin
- Bulking sludge in the clarifier (filamentous organisms)
- RAS rate too low causing high clarifier sludge blanket (sludge can become septic and rise to the top - denitrification)
- Peak flow very high and washes out solids

## Internal Organic and Hydraulic Loading Issues

- High return rates from sludge thickening and supernatant from sludge processing can cause very high concentrations of ammonia and BOD
- High scum return rates from the clarifier can cause hydraulic overloading

## Clarifier Issues

- Clarifier weir cleaning – block and return to head of plant or screen and return water to head of plant, clean weirs more often, install brushes
- Inadequate scum collection (grease, sludge, debris discharges)
- Solids collecting on piping and walls in clarifier will eventually discharge

## Screen for Clarifier Weir Cleaning and/or Scum Return

## Tablet and Liquid Chlorination

- Chlorine needs to be fed into the plant according to the amount of flow
- Wrong type of chlorine tablets may cause problems

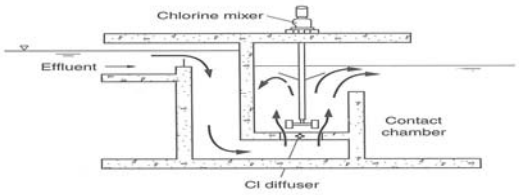
## Gas Chlorination Issues

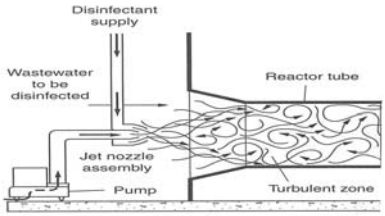
- Needs to have automatic switchover capabilities
- Problems with the feed system
- Problems with the feed system when the chart range is set too high

## Gas Chlorination

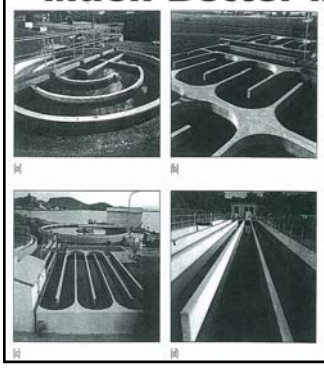
## Chlorine Contact Chamber

- Must have 20 minutes detention time at actual peak flow
- Baffled correctly, no short circuiting
- No excess sludge settled in chamber
- Aeration in the chlorine chamber requires more chlorine to be fed can cause short circuiting
- Proper Mixing



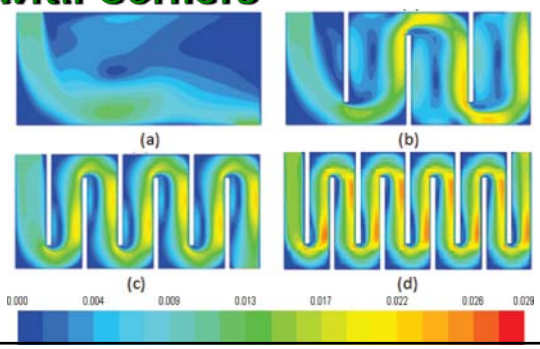




## Rounded Corners Provide Much Better Mixing



- Ideal: Length to Width Ratio - 40:1
- Depth to Width Ratio - 1:1
- Consider Wind Action (could cause short circuiting)

## Poor Mixing in Rectangular Chambers with Corners

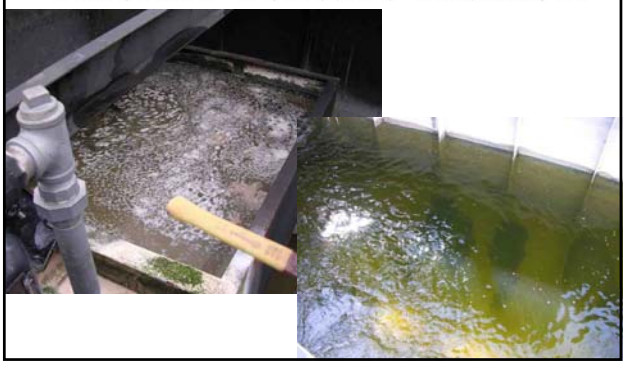



## Capacity for 2-hour Peak Flow

## Too Much Aeration

## Adequate Baffling in the Chlorine Contact Chamber

## Excess Solids in the Chlorine Contact Chamber



## Sludge Accumulation in the Chlorine Contact Chamber

## Sequencing Batch Reactors and Chlorine Chambers

- Sequencing Batch Reactors need to have constant flow through the chlorine contact chambers or assure the 20 minute detention time is met for all of the water during batch discharging

## Chlorination Chemistry

- Chlorine Compounds:
  - Chlorine = $Cl_2$
  - Through Hydrolysis:

    $Cl_2 + H_2O \leftrightarrow HOCl + H^+ + Cl^-$

    $HOCl \leftrightarrow H^+ + OCl^-$
  - Hyprochlorous acid = HOCl
  - Hypochlorite ion = $OCl^-$

## Chlorination Chemistry

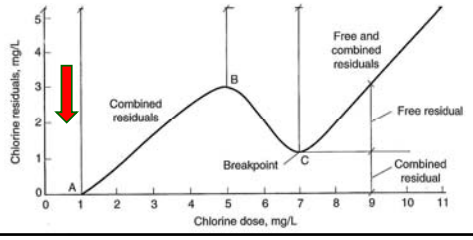
- Ammonia Compounds: NH3-N
- Chloramine Compounds:
  - Monochloramine = $NH_2Cl$
  - Dichloramine = $NHCl_2$
  - Tri-chloramine = $NCl_3$

## Chlorination Chemistry

- Typical Influent Ammonia Concentration = 30 mg/l $NH_3$-N
- Simultaneous Nitrification / Denitrification > 90% removal
- 3.0 mg $NH_3$-N requires 27 mg/l $Cl_2$ to achieve breakpoint
- Lower $NH_3$-N concentrations at WWTP outfall is a result of $NH_3$-N oxidation by $Cl_2$

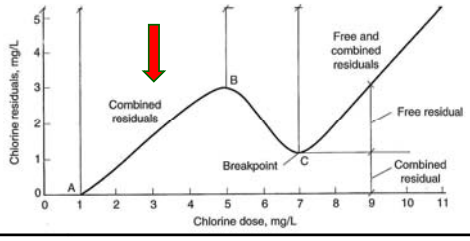
## Chlorination Chemistry

- Step 1 – Competing Reactions
  - Organics, $Fe^{2+}$, $Mn^{2+}$, and $H_2S$
  - Result = No Chlorine Residual, No Disinfection Capability



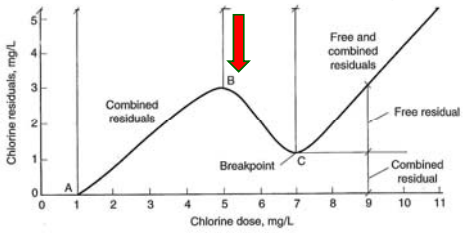

## Chlorination Chemistry

- Step 2 – Formation of Mono-chloramine
  - $NH_3 + HOCl \rightarrow NH_2Cl$ (monochloramine) + $H_2$
  - Result = Increasing Chlorine Residual, Weak Disinfection Capability

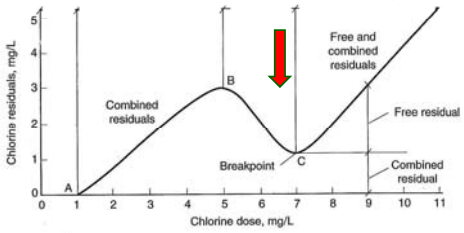


## Chlorination Chemistry

- Step 2 – Formation of Mono-chloramine
  - Theoretical Weight Ratio: 71 mg $Cl_2$ to 14 mg N = 5.1:1
  - "Real world" Weight Ratio: ≈ 6.5:1

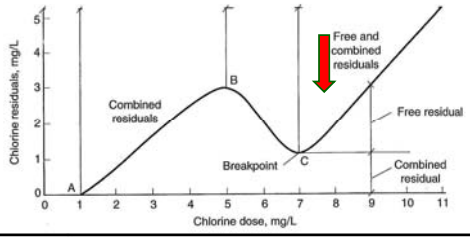



- Step 3 – Formation of Di- and Tri-chloramines
  - $NH_2Cl + HOCl \rightarrow NHCl_2$ (dichloramine) + $H_2O$
  - $NHCl_2 + HOCl \rightarrow NCl_3$ (nitrogen tri-chloride ) + $H_2O$
  - Result = Lower Chlorine Residual, Lower Disinfection Capability



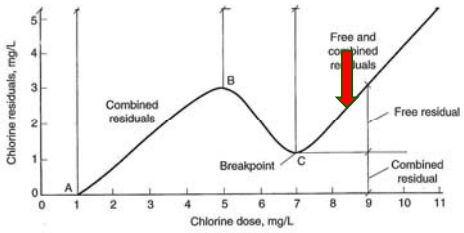

## Chlorination Chemistry

- Step 4 – Breakpoint
  - Result= Oxidation of all ammonia and competing substances



## Chlorination Chemistry

- Step 5 – Formation of Free Chlorine
  - Result = Begin to Form Free Chlorine; Much Stronger Disinfection Capability

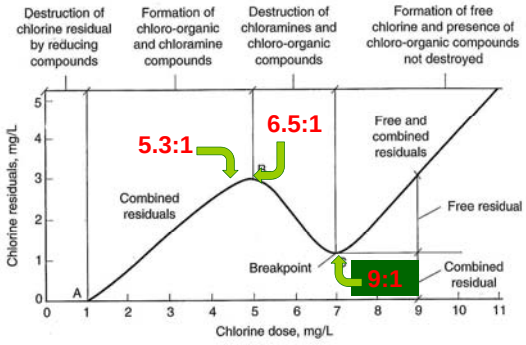



## How Much Chlorine is Required?

Theoretical Weight Ratio = 7.6 mg $Cl_2$ to 1 mg N

"Real World" Weight Ratio = 8:1 to 10:1

## Example For a 1.5 mg/L Ammonia Coming Into the Chlorine Chamber



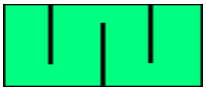
## Chlorination Curve

- Monochloramines are a much stronger disinfectant than di and trichloramines, however, Total Chlorine Residual does not distinguish between the forms of chloramine

## Chemical vs UV Treatment

Chemical Disinfection

CT = Concentration x Contact Time



UV

IT = Intensity x Contact Time

## Ultraviolet Light Systems

- Adequate Capacity
- Engineer may spec a certain size system but, that size doesn't get installed
- Approach channel must be a least 4 feet in length and unobstructed
- Downstream channel must be 4 feet in length and unobstructed

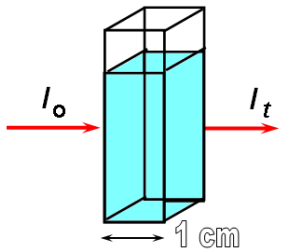
## Ultraviolet Light Systems

- The flow regime through the bulbs must be adequate so that light can penetrate all of the water
- Regulated by flow and equal across channels – lights turn on and off automatically as flow increases or decrease
- Intensity readings on UV bulbs must be sufficient/constant over lifetime of bulbs
- Transmissivity vs. Age of bulbs
- Hours of operation monitored

## Ultraviolet Light Systems

- Transmissivity a measure of the wastewater's ability to transmit UV light at the germicidal wavelengths
- Some other states have a permit limit for Transmittance (T10)
- T10 would be the percent of UV radiation flux power remaining after passing through a layer of 10 mm in thickness, measured at a wavelength of 253.7nm

## UV Transmittance



## UV Spectrum

- UV is part of the electromagnetic spectrum between visible light and x-rays.
- The portion between 185-400nm has a strong germicidal effect, disrupting the DNA, rendering them unable to reproduce

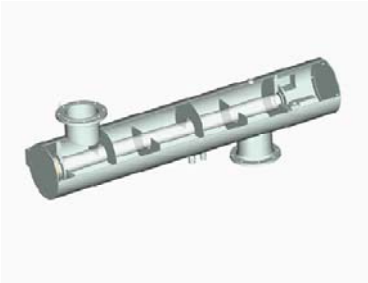
## Different Types of Lamps

- Medium pressure UV produce an abundance of 265 nm and other wavelenths
- Microbial DNA absorb this wavelength most effectively
- Low pressure UV produce a single peak output of 254 nm
- According to studies, some microbes can repair themselves after this wavelength once exposed to sunlight again

## Different Types of Lamps

- It's thought that the exposure to other wavelengths may have an effect on other intracellular molecules such as RNA and enzymes, which are unable to repair themselves

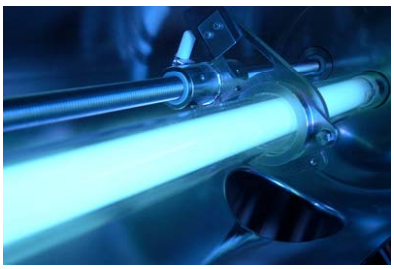
## Ultraviolet Light Systems



## Ultraviolet Light Systems

- Suggested cleaning solutions may not work
- UV bulbs must be clean and clear
- Don't want to scour bulb sleeves with cleaner
- Total Suspended Solids in the effluent must be low
- Bird droppings can cause contamination

## UV Bulb, Sleeve, and Wiper



## UV System

## UV System

## UV Bulb Cleaning

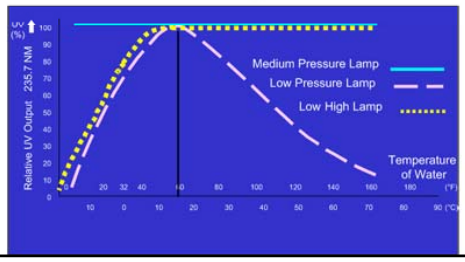
## UV Wiper System

## Ultraviolet Light Systems

- Sequencing Batch Reactors need to have constant flow through the UV system or the bulbs must be warmed up prior to discharging to UV basin (which would require a certain water level in the UV basin at all times

## Temperature vs. Type of Lamp

### Fluid Temperature and UV Lamps



## Temperature vs. Type of Lamp

- <10 degrees C = <50 degrees F
- Low pressure UV drops off dramatically, while medium pressure UV is almost unchanged, even below freezing.

## Ponds/Lagoons

- Additional disinfection unit is not required if there is 21 days detention time in pond/lagoon
- Demonstrate by an influent meter and capacity
- However, if you meet the limit then may have to add disinfection or change flow through pond/lagoon

## Sampling

- Operators must be trained on how to sample for bacteria
- Lab sample collection personnel must be observed to assure proper technique
- May need different sampling equipment
- Intent is to sample at peak flow
- Hold Time – 6 hours from time of collection to lab