

The background image shows an industrial facility, likely a water treatment plant. It features large, green-painted pipes and complex machinery. In the foreground, there are large, cylindrical, light-colored components, possibly part of a cooling tower or filtration system. The floor is concrete, and the ceiling has exposed pipes and lighting fixtures. The overall scene is industrial and technical.

Water and Energy Conservation with Ozone Treatment of Cooling Towers to Improve Sustainability

Presented by LaMotte Water
Management



Stand-alone Ozone Treatment for Cooling Towers

- Improved Sustainability with Energy Conservation Through the Removal of Bio-Film
- Improved Sustainability with Water Conservation Through Increased Cycles of Concentration
- Additional Benefits –
 - Removal of all hazardous chemicals
 - Minimization of infectious disease hazard
 - Reduced maintenance

Cooling Tower Problems

- Corrosion:
 - reduces equipment service life
- Scaling:
 - increases energy cost
 - 1 mm scale \approx 10% increase in electrical demand
- Deposits
 - Decreased efficiency
 - Increased labor costs
- Microbiological growth- Biofilm
 - Reduced heat exchange
 - Up to 5X more than the same thickness of mineral scale
 - Liability (Legionella and other infectious diseases)

Water Treatment Solutions

- Short Comings of Standard Solutions

- Chemicals

- Hazardous and requires handling precautions
 - Requires substantial facility labor
 - Continual high cost for quality program
 - Environment precautions necessary

- Filtration

- Must always be combined with other programs

- Mechanical/Electromechanical

- No proven effectiveness against biological growth
(see University of Pittsburg study)

Ozone Cooling Water Treatment

- Replaces all chemical programs for the tower
- Reduces water usage
 - @ 2.5 to 5.0 million gallons/year per 1,000 tons of cooling tower)
- Provides safer, more effective:
 - Microbiological control
 - Corrosion control
 - Scale control
- Protects welfare of clients and staff by reducing potential for airborne contagion (Legionella) and toxic chemicals
- Environmentally friendly
- Less maintenance required-fewer cleanouts

What is Ozone?

- O_3 - an unstable form of oxygen with three atoms
- Powerful oxidizing biocide
 - 500% more effective than chlorine
- Short life in evaporative cooling water (around 15 minutes)
- Environmentally Safe - breaks down to oxygen

Benefits of Ozone

- Helps Keep system cleaner
 - Mechanically – by removing bacteria from the system, mechanical cleaning is much easier
 - Chemically - removes need for hazardous chemicals while providing superior performance
- Reduce Food
 - Filtration - often not necessary
 - Oxidation - far superior to chlorine, bromine, chlorine dioxide, etc. Not effected by system debris or pH
 - Location of Equipment - still must be addressed, but not as critical
 - Process Leaks – oxidizes organic process leak materials, reducing food and fouling

What does the ozone actually do?

- Disinfects the water- no bacteria is known to be immune to ozone
- Oxidizes organics- Cold Combustion
 - Bacteria and Nutrients
- Permits “cycling up” cooling tower water
 - “Cycling up” is when system water is allowed to evaporate until the mineral salt concentration is 5-12 times that of the makeup water. (cycles of concentration) The water is now alkaline. The pH is high, so general corrosivity of the water is reduced.

Energy Conservation Through the Removal of Bio-Film

University Chiller Plant Study

Study was to demonstrate minimum of almost 4% energy savings on new chiller through the removal of bio-film on water cooled condenser heat transfer surfaces measured by reduction in fouling factor.



Energy Savings

- Thermal Conductivity
 - Calcium Carbonate 2.6
 - Calcium Phosphate 2.6
 - Calcium Sulfate 2.3
 - Iron Oxide 2.9
 - **Bio-film** 0.6
- Bio-Film is 5 times more insulating than scale.

Energy Savings – Data Collection

- Fouling Factor

- Data collected prior to changeover to Ozone
- Data collected after changeover to Ozone

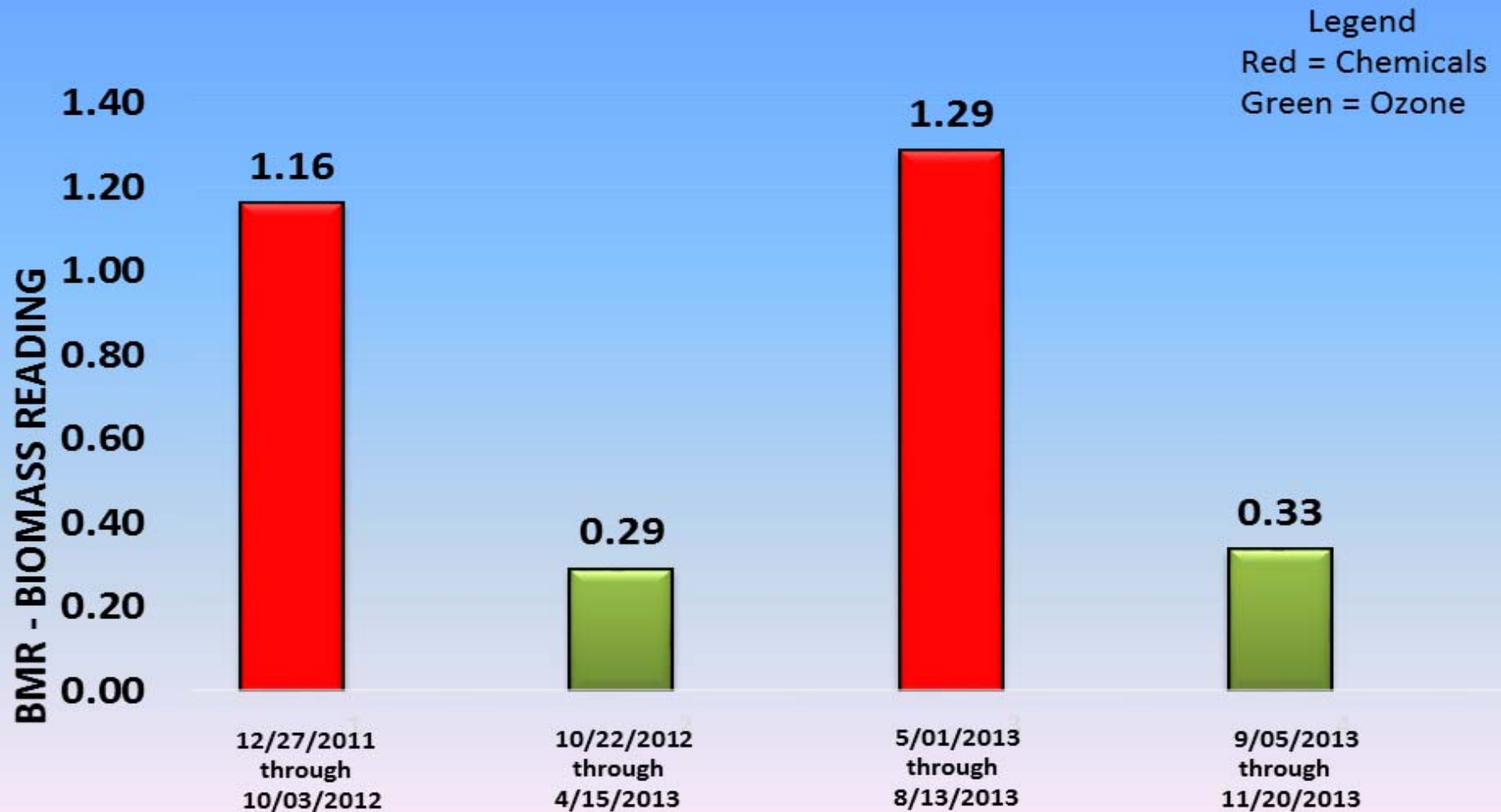
- Bio-film

- Readings collected with the use of a coupon and results from a 15 minute reaction – all readings in BMR, or Bio-Mass Reading
- Range – from <0.3 indicating no growth to >2.5 indicating severe Bio-fouling
- Average readings prior to changeover to Ozone
- Average readings after changeover to Ozone

Ozone Destroys Biofilm

While readings in the 1.00 to 1.75 range indicate a biofilm program under control, reading below 0.30 are considered no growth

BioMass Readings – BioFilm Testing



Energy Savings - Program Results

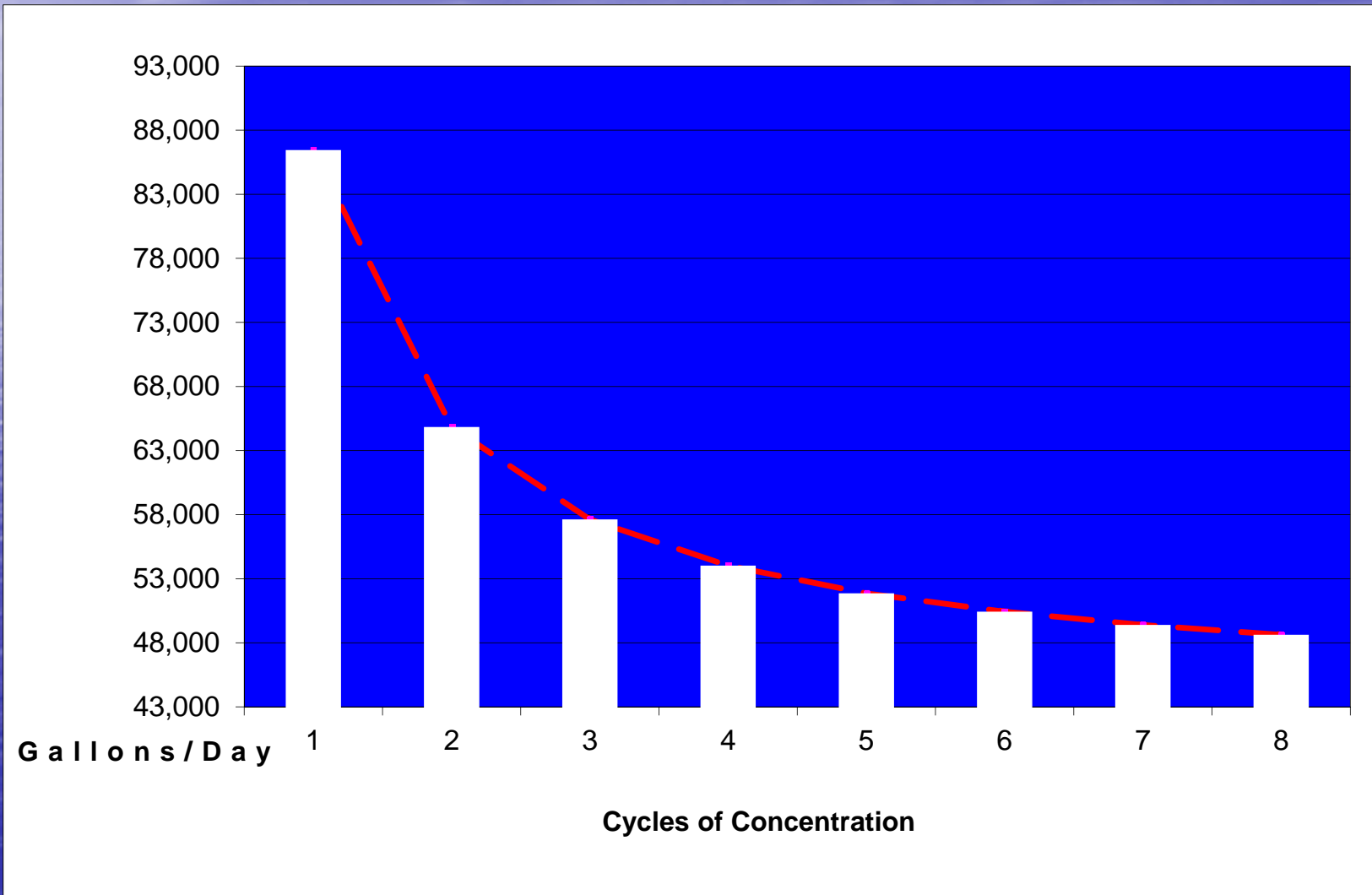
- Electrical Savings of 3.58%
- Fouling Factor Improvement of 17% Over Chemical Program
- Significantly Higher Savings When Chiller Load Above 840 Tons (on a 1200 Ton Chiller)
- Bio-film Readings Significantly Reduced
- Corrosion Rates Maintained in the Excellent Range
- Eddy Current Test Results Identify No Impact
 - Results of Test Backed by Excellent Copper Corrosion Results

Water Conservation by Increased Cycles of Concentration

With the use of Ozone

- System is kept significantly Cleaner
- Bio-Film is removed from heat transfer surfaces
 - No "glue" to attach scale to tubes
 - No insulating biofilm
- Can increase the saturation index, allowing higher levels of scaling minerals in the tower water
- Increased minerals = higher COC = Decreased bleed
- Bleed can be discharged to environment or reused

Water Conservation in a 1,000 Ton Cooling Tower



Water Savings

	Chemicals	Ozone
Cycles of concentration	3	6
Evaporation rate-gals/day	43,200	43,200
Blowdown rate-gals/day	21,600	8,640
Makeup + sewer cost/year	\$118,575	\$74,393

Total annual water cost savings: \$44,182

Total water saved: 4,730,400 gallons

Total Annual Savings

	Chemicals	Ozone
Treatment Cost/yr:	\$17,500	\$3,750
Total Operating Cost/yr.:	\$644,175	\$578,969
Total Cost/yr.:	\$661,675	\$582,719
Savings with ozone:	\$78,956/yr	

(Simple payback: 13.1 months to recoup a capital outlay of \$85,700 for ozone system)

Additional Water Savings Through Water Reuse

- Discharge to Storm
 - Reduced sewer cost
- Irrigation
 - Reduced water purchased
- Replenish Aquifer
 - Benefit the environment
 - Reduce water shortages
- Surface Wash-down
- Gray Water Systems



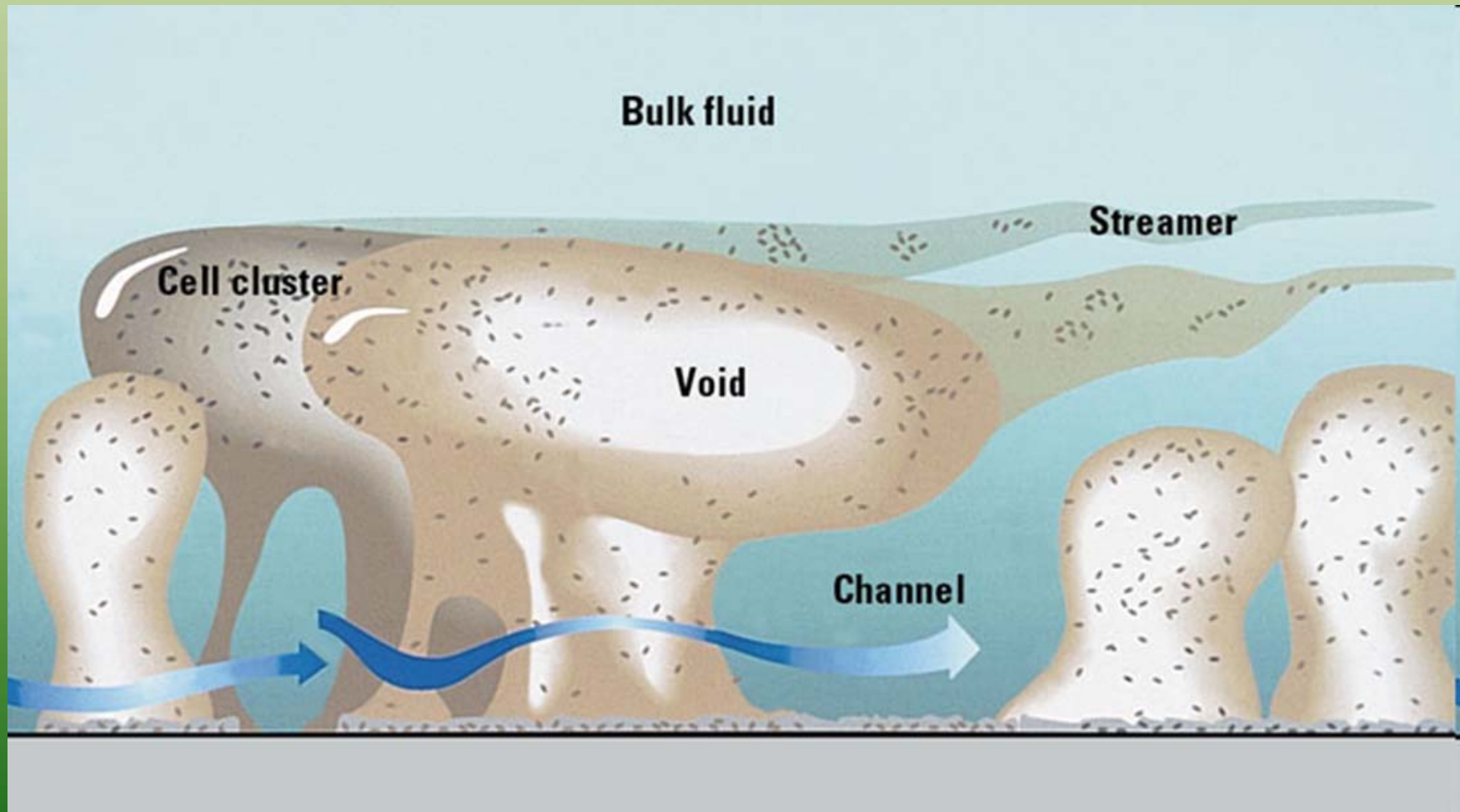
Bacteria and Viruses

- Ozone Treatment greatly reduces bacteria and virus levels in cooling towers
 - Typically less than 10^2 colonies/ml (W.H.O.)
 - Toxic to microbiological
 - Cold combustion rather than poisoning
 - Reduces food supply
- Greatly reduces risk of infection from cooling water
- No known bacteria or virus is immune to ozone including Legionella and cryptosporidium
- Reduced bacteria means reduced biofilm

Legionella Pneumophila

- Since 1970 there have been an estimated 10,000 to 20,000 cases annually
- 4,000 cases yearly result in death
- New York State Law – Tower Registration
- Legionella
 - Pneumonia like symptoms or
 - Flu Like Symptoms (Pontiac Fever)
- Invades white cells in lungs and multiplies
- Naturally present in surface water sources
- Common in cooling towers and potable water systems
- Very susceptible to continuous oxidizing chemicals (I.E. ozone, chlorine)

Porous Mixture of Organic and Inorganic Material





Biofilm Prevention and Removal

- Keep system clean
 - Mechanically - physical removal
 - Chemically- micro-biocides, dispersants
- Reduce Food
 - Filtration
 - Oxidation
 - Location of Equipment
 - Process Leaks

**Bacteria Count* in School's
Cooling Tower Water,
A Comparison:
Clean Streams™ 'Ozone' System
Versus
Chemical Treatment**

Tower #1

Chemically Treated

$10^6=1,000,000/\text{ml}$



Tower #2

Chemically Treated

$10^5=100,000/\text{ml}$



Tower #3

Ozone Treated

0/ml



Ozone/Cooling Tower Summary

- Cooling Towers account for 40-80% of a building's water consumption
- Uncontrolled bacterial growth can occur in a campus or building's cooling tower water
- Ozone is the most powerful, safest biocide to date for use in cooling towers
- Ozonated discharge water may be reused for a variety of purposes
- Ozone systems vary in sizes and performance
 - MTE and units long term history are important factors in selection

Benefits of Ozone

- Maximize Water Savings
 - Millions of gallons saved through reduced system bleed
- Increased Energy Efficiency – 4% to 10% or More
 - 1 mm of biofilm decreases tube efficiency by 10%
- Minimization of Risk to Infectious Disease
- Cleaner Systems Increase Equipment Longevity
- No Chemical Drums to Move, Spill, or Dispose



Benefits of Ozone

- Removal of Chemical from Site
- No Exposure of Facility Population to Hazardous Chemicals
- Lower Bacteria Counts - <100 CFU
 - World Health Organization says should not see Legionella with counts below 100 CFU
- Reduced Maintenance and Cleaning
- No Chemicals in Water
 - Can be discharged to environment
 - Water reuse
 - Irrigation

