

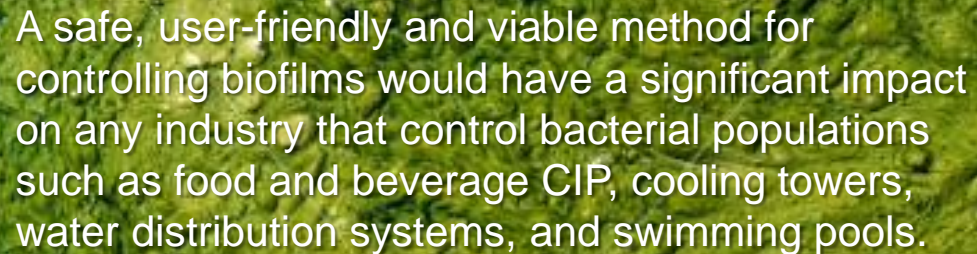


 *The **SAFEST WATER** In The World*

Module: Biofilm and Algae Removal

Biofilms :

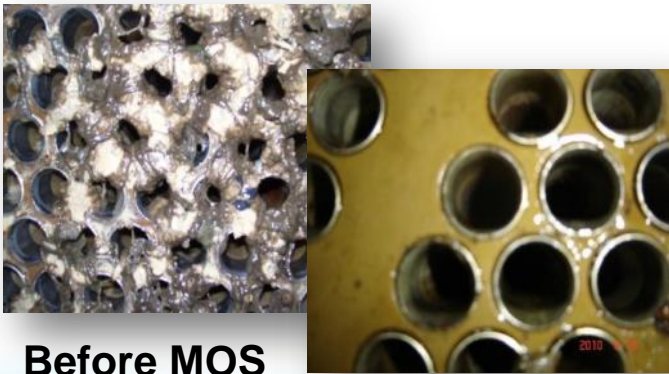
- ▶ are communities of microorganisms encased within an extracellular polymeric slime (EPS) matrix living on surfaces.
- ▶ are typically composed of many species of microorganisms, including bacteria fungi, algae, and protozoa.
- ▶ are difficult to remove once initial adhesion occurs.
- ▶ are found in aqueous environments and are often resistant to disinfection.
- ▶ can shelter disease-causing microorganisms, such as *Legionella*, *Listeria*, and temperature resistant bacterial spores.



A safe, user-friendly and viable method for controlling biofilms would have a significant impact on any industry that control bacterial populations such as food and beverage CIP, cooling towers, water distribution systems, and swimming pools.

Why MOS for Biofilm removal:

- ▶ It is most likely that the observed effects of MOS on removing biofilm are related to its ability to damage existing EPS
- ▶ The mechanism is not yet known
- ▶ MIOX scientists are working with 3rd party researchers to determine the mechanism
- ▶ We have observed the effects repeatedly in the field and in the lab
- ▶ Our current thinking is that the combination of oxidants work synergistically to break up and dislodge the EPS from the surface, thereby removing the biofilm



Before MOS

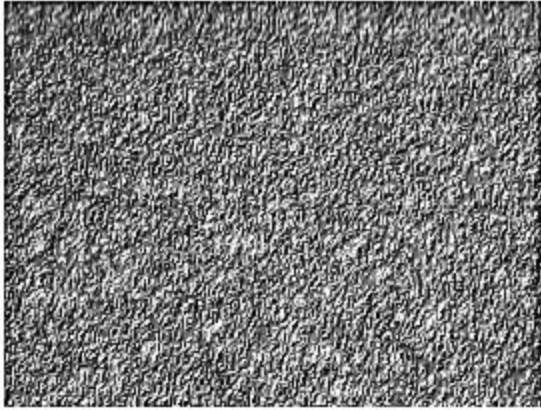
After MOS



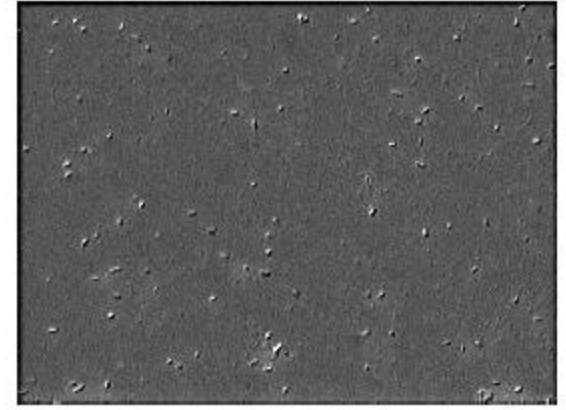
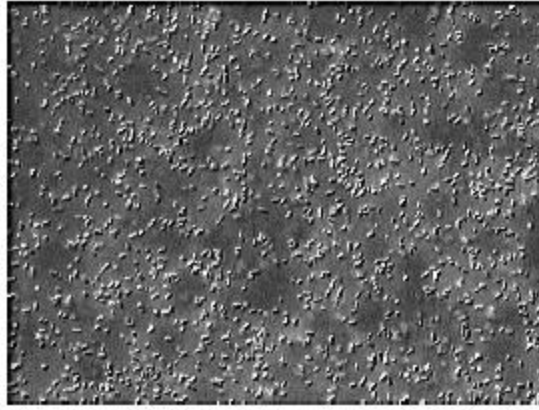
Before MOS

After MOS

Unlike bleach, MOS removes *Pseudomonas putida* biofilm **including the EPS.**



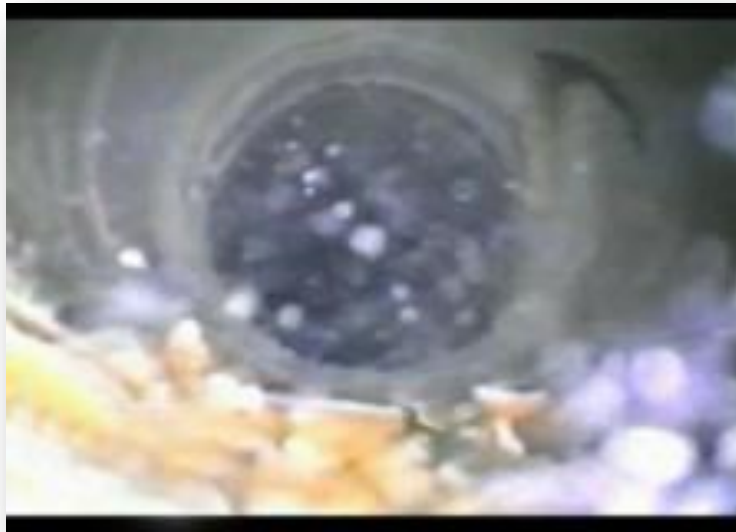
At 35 minutes:
Unchecked biofilm growth



At 5:40
Biofilm cells nearly undetectable

“MOS destroys not only the biofilm, but the house it lives in...”

Borescope Video Images Reveal Biofilm Removal at Ainono Hot Springs, Japan



Filter recirculation pipe with sodium hypo



Filter recirculation pipe 22 days after MOS

Field Evidence - MOS Removes Biofilms from Distribution Systems

- ▶ Direct (visual)
 - Diana WSC in TX, 2 line breaks occurred simultaneously
 - At a KOA campground in Great Falls, MT, mixed oxidant solution removed heavy biofilm in 2 weeks and eliminated coliform hits
- ▶ Indirect
 - More consistent, lower residual at same dose
 - Lower TTHMs in the distribution system



Left: Pipe treated with **chlorine alone** – a biofilm slime is visible; only 200 feet from disinfection station.

Right: Pipe treated with **MOS** 0.5 miles from disinfection station

Shibasaki Pool in Tachikawa City, Japan

Visible difference in water clarity



4-5 days after MOS use

Hospital Case Study:

Biofilm removed, *Legionella* non-detectable in 8 days

Day	<i>Pseudomonas</i> (CFU/mL)	<i>Legionella</i> (CFU/L)
Day 0	0-95	Detected
Day 5	60 (hot) 0 (cold)	ND/1 L
Day 8	0 (all points)	ND/1 L

- ▶ In 2006, water system non-compliance delayed hospital commissioning.
- ▶ *Legionella* and *Pseudomonas* (a biofilm-former) were consistently detected despite use of chlorine dioxide (0.5 ppm dose) to clean the system.
- ▶ A premise plumbing case study was designed with the goal of cleaning the system in a short period of time using MOS.
- ▶ Disinfectant residual and bacterial sampling conducted at 1400 sampling points.
- ▶ Within 8 days, MOS dosed at 50 ppm showed non-detectable *Pseudomonas* and *Legionella* counts, an indication that biofilm had been controlled.



Bottling Plant in Mexico

Improved microbiological results



- ▶ **Three bottling facilities**
- ▶ **Mixed Oxidant applications include:**
 - Cold Clean-in-place
 - Intake Water
 - Cooling Towers
 - Wastewater Disinfection
- ▶ **Purchase Drivers include:**
 - Less than a year payback based on chemical usage
 - Reduced water and energy usage
 - Improved microbiological results
 - Reduced CIP time by approximately 40%
 - Meets environmental and sustainability goals

Bottling Plant (Carbonated Beverages) Mexico

Mixed oxidant for multi-point beverage application yields significant cost savings



- ▶ MIOX[®] RIO M2 Mixed Oxidant
- ▶ Installed June 2010
- ▶ Clean-in-Place
- ▶ Dosed in potable water treatment
- ▶ Wastewater
- ▶ Cooling towers
- ▶ External sanitation
- ▶ 45 CIP operations consecutive positive
- ▶ Cost savings expected: \$100,000/year over chemicals

Bottling Plant (Carbonated Beverages) Mexico

MOS chosen for advanced benefits, biofilm removal



- ▶ MIOX[®] RIO M2 Mixed Oxidant
- ▶ Piloted May 2010
- ▶ Clean-in-Place
- ▶ Dosed in potable water treatment
- ▶ Wastewater
- ▶ External sanitation
- ▶ Iron content reduced from 5 ppm to 0.01ppm
- ▶ Positive flocculation results
- ▶ Cost savings expected: \$150,000/year over chemicals



Power Generation Station, Puerto Rico

Biofilm removal in power plant & cooling tower



MIOX on-site generator in portable building



Biofilm with conventional biocide program



Biofilm eliminated with mixed oxidants



NIPSCO – Northern Indiana Power Plant

Saving over \$150,000/year in chemical costs for one tower



**Condenser Tube Sheet
BEFORE MOS**



**Condenser Tube Sheet
AFTER MOS**

- ▶ MIOX[®] 300 ppd Mixed Oxidant RIO[™]
- ▶ Replaced both chlorine and bromine for cooling tower water disinfection
- ▶ Partial retrofit using existing tanks
- ▶ Reduced price of disinfectant/oxidant by generating it on-site
- ▶ Generating a safer chemical below the 1% threshold for consideration as a hazardous material
- ▶ Improved chemical efficacy
- ▶ Reduced maintenance

“Reducing our treatment regimen ...down to a single mixed oxidant product generated on site has resulted in substantial treatment chemical and labor cost savings.” -- Paul Schrock, NIPSCO Senior Chemist



Thermal Chicago Cooling Tower

Algae and Biofilm Issues Solved



- ▶ Cooling basin cleared of algae in 2 weeks; biofilm cleared in 4 weeks
- ▶ No degradation of scale and corrosion inhibitors (phosphonates, polymer or azole)
- ▶ Low corrosion – mild steel corrosion rates at 0.9 to 1.4 mpy, yellow metal corrosion at <0.1 mpy
- ▶ Excellent microbial control even at elevated pH
- ▶ Easy to operate and maintain
- ▶ Eliminated 28,500 lbs of sodium hypo and isothiazolin and subsequent disposal of 51 chemical drums

Westerly, Rhode Island Water System

Successful biofilm control for potable water



- ▶ C&E engineering lead evaluation for conversion from chlorine gas
- ▶ Installed 6 MIOX systems at 2 plants
- ▶ Better residual maintenance throughout distribution, including biofilm control
- ▶ Studies indicate improved corrosion control over liquid bleach

"We have found the MIOX system to meet our high safety requirements, plus there are reduced maintenance costs." - Chris Duhamel, PE



West Columbia, South Carolina:

Biofilm removal in municipal application



- ▶ Gradual reduction in biofilms in the clearwells and distribution
- ▶ Chlorine residual stability allowed lower mixed oxidant solution dosing at the plant
- ▶ TTHM and HAA5 concentrations steadily declined
- ▶ Conversion from chloramination using chlorine gas and anhydrous ammonia (gas) to FAC as MOS resulted in improved plant safety and chemical cost savings

Las Vegas, New Mexico:

Algae Removal at 3.5 MGD SWTP



- ▶ 42% reduction in alum use
- ▶ 44% reduction in formation of TTHMs
- ▶ 15% to 30% reduction in FAC dose with an increase in chlorine residual from 0.2-0.3 ppm to 0.8-1.0 ppm
- ▶ Sponge and algae growth in clarifiers reduced from 1.5" per month to 0"
- ▶ Eliminated maintenance of 20 hours spent scrubbing away algae mat every 3 weeks
- ▶ Eliminated taste and odor complaints