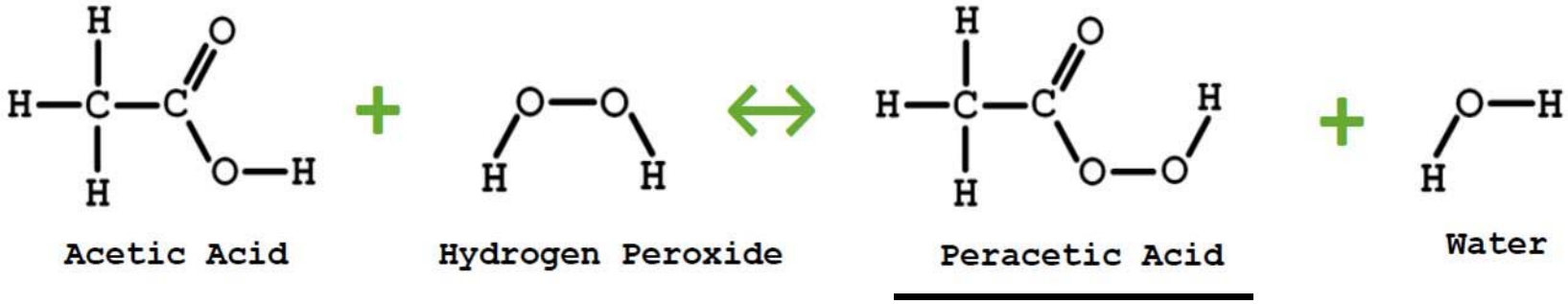
Implementing Peracetic Acid – Piloting, Pumping, & Storing PAA Safely

CWP KY&TN
Jim Pelton – Pelton Environmental
JimPelton@PeltonEnv.com

Definition

An **organic peroxide** that results from the reaction between Acetic Acid, Hydrogen Peroxide and Water.



PAA exists only in **equilibrium** with the other components in aqueous solution.

PAA is a strong **disinfectant** and a strong **oxidant**.

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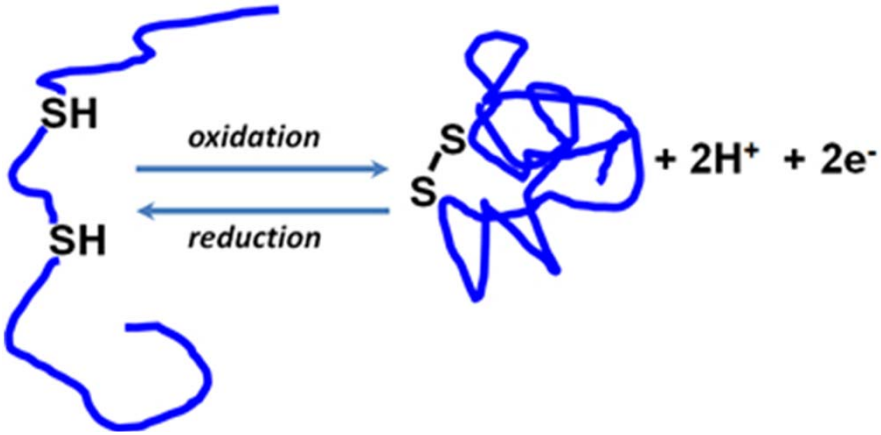
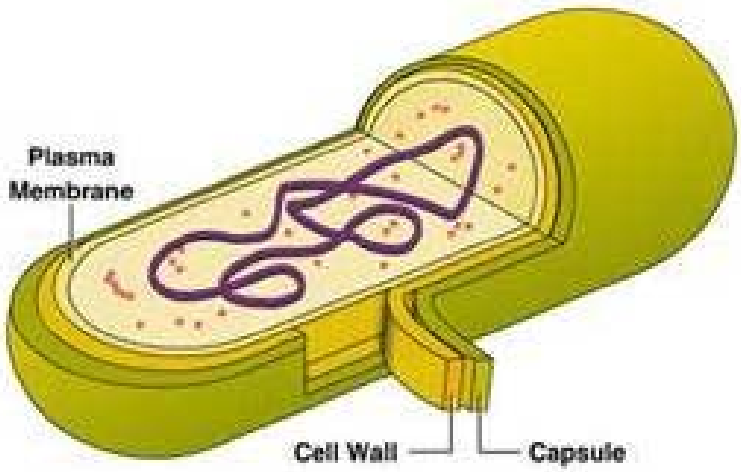
Strong Disinfectant

PAA oxidizes **enzymes** (proteins) and **nutrients** inside bacteria cells, rendering them unviable.





These mechanisms enable PAA to disrupt bacteria effectively and efficiently (**low doses, short contact times**)

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Strong Oxidant

The standard oxidation potential (at pH 7) of PAA is higher than most common oxidants.

Oxidant	Standard Potential (V)
Hydroxyl Radical	2.80
Ozone	2.07
Peracetic Acid	1.81
Hydrogen Peroxide	1.78
Potassium Permanganate	1.68
Chlorine Dioxide	1.57
Chlorine	1.36

PAA is a strong and effective oxidant - readily attacks bacteria as well as organic pollutants

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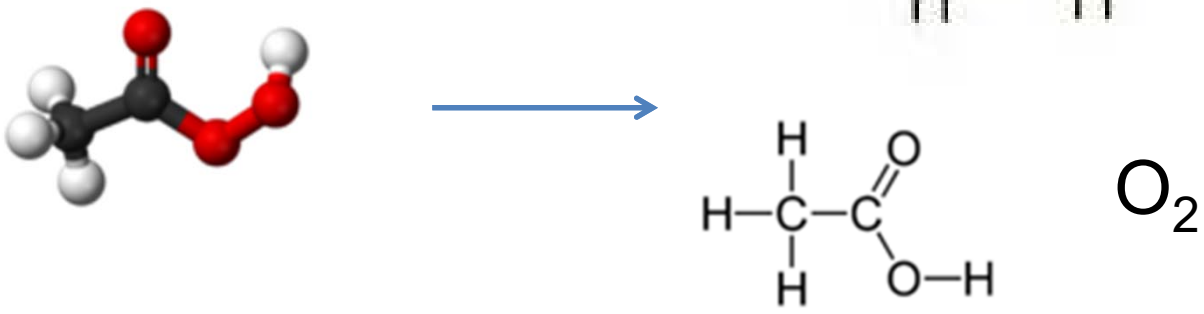
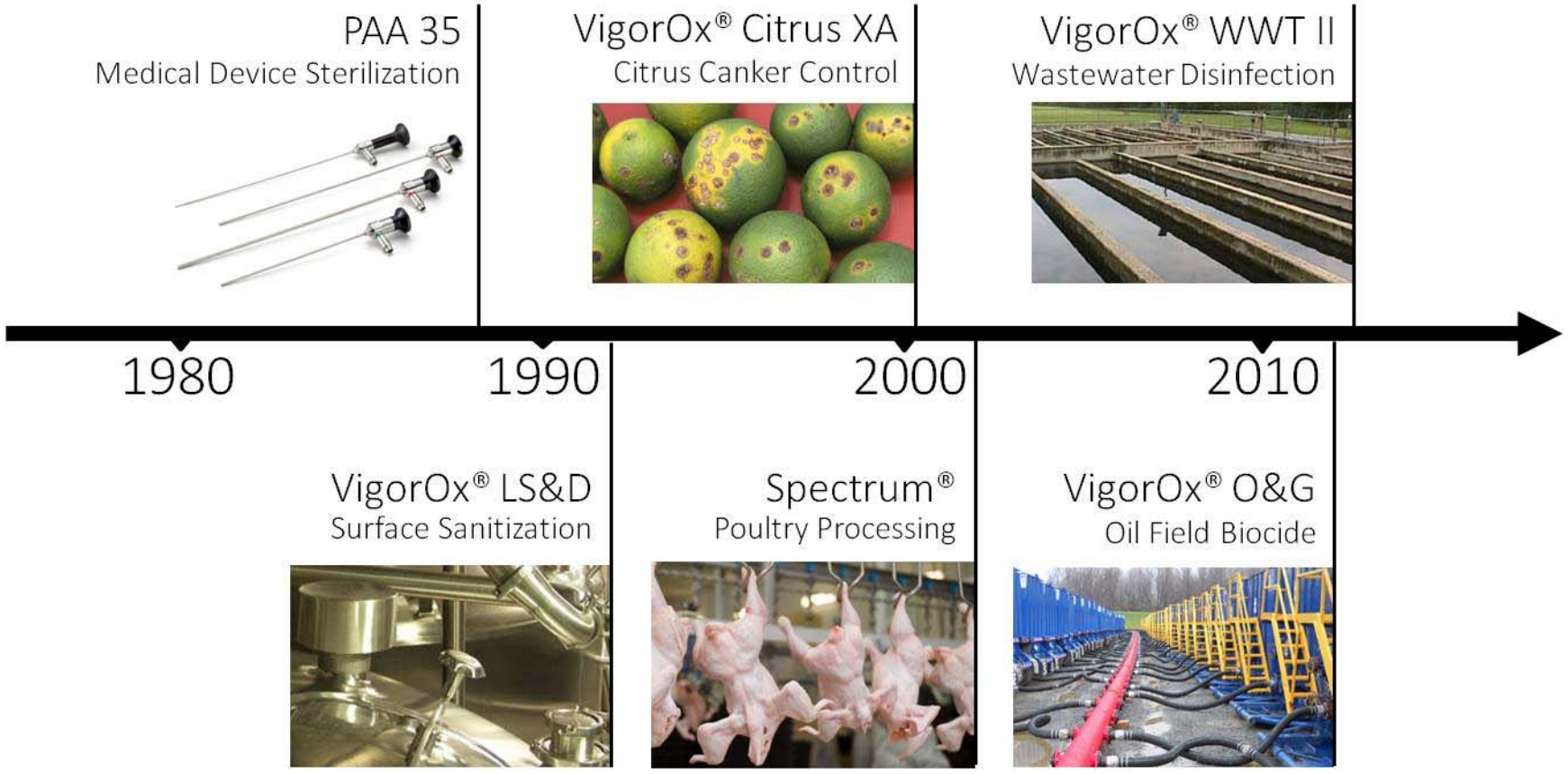
Peracetic Acid in Wastewater

- PAA breaks down to water, oxygen and acetic acid (vinegar) upon reaction with microbes, organics, TSS and auto-decomposition



Uses in Microbial Control



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PART 2

Wastewater Disinfection

- Formulation
- EPA Label
- Efficiency
- Kinetics in Wastewater
- Properties
- Drivers for Conversion
- Conversion Steps

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Formulation

PeroxyChem's peracetic acid formulation for wastewater disinfection is registered and labeled as VigorOx® WWT II

VigorOx® WWT II
Wastewater Disinfection Technology

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Formulation

Equilibrium can be achieved at different *PAA:H_2O_2:AA* ratios

- Increasing H_2O_2
  - Helps reduce PAA demand, reduces overall usage
  - Increases Dissolved Oxygen (DO)
- Increasing Acetic Acid
  - Increases BOD

	VigorOx	Solvay	Envirotech
Peracetic Acid	15%	12%	22%
Hydrogen Peroxide	23%	18%	5%
Acetic Acid	16%	20%	45%
BOD (mg/L)	1.98	2.62	3.02
DO (mg/L)	0.93	0.94	0.32
Net BOD (mg/L)	**1.05**	**1.68**	**2.70**

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US EPA Label

VigorOx® WWT II

EPA Registration No. 65402-8

- Dose range: 1 - 25 ppm
- Maximum Residual : 1 ppm ($DF < 12$)

  or

  $0.09 * DF$ ppm ($DF > 12$)

$$DF = \frac{plant\ effluent + receiving\ stream\ 7Q10}{plant\ effluent}$$

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Properties

Formulation	VigorOx® WWT II
Normal State	Liquid
Odor	Pungent “vinegar” smell
Density	1.16 g/mL (9.67 lb/gal)
Freezing point	-56 ˚F
pH	< 1
Solubility	Completely soluble
Stability	1 year at T < 84 ˚F
NFPA	

- Flammability: flashpoint above 200 ˚F
- Health: short exposure cause injury
- Reactivity: decomposition at high temperature
- Oxidizer

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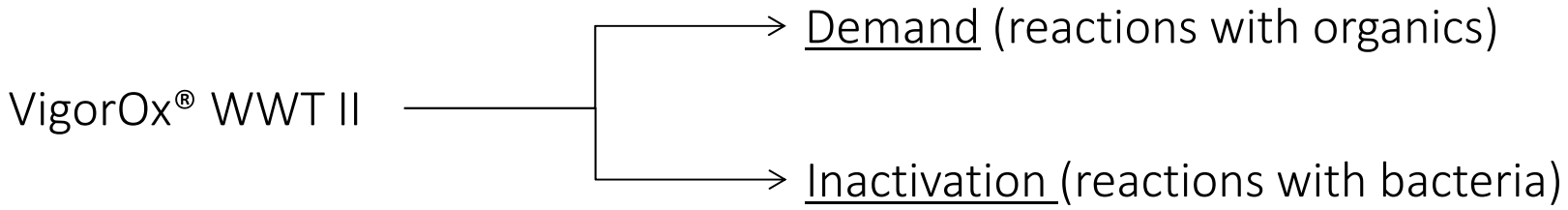
Reactions in Wastewater

When **VigorOx WWT II** is added to **wastewater**, multiple reactions take place:



The inactivation and demand kinetics impacts the overall **efficiency** of PAA Disinfection (dose & contact time).

- Hydrogen Peroxide helps satisfy demand, improving efficiency
- TSS has little impact on efficiency
- Ammonia, nitrates and nitrites do not impact PAA performance or demand

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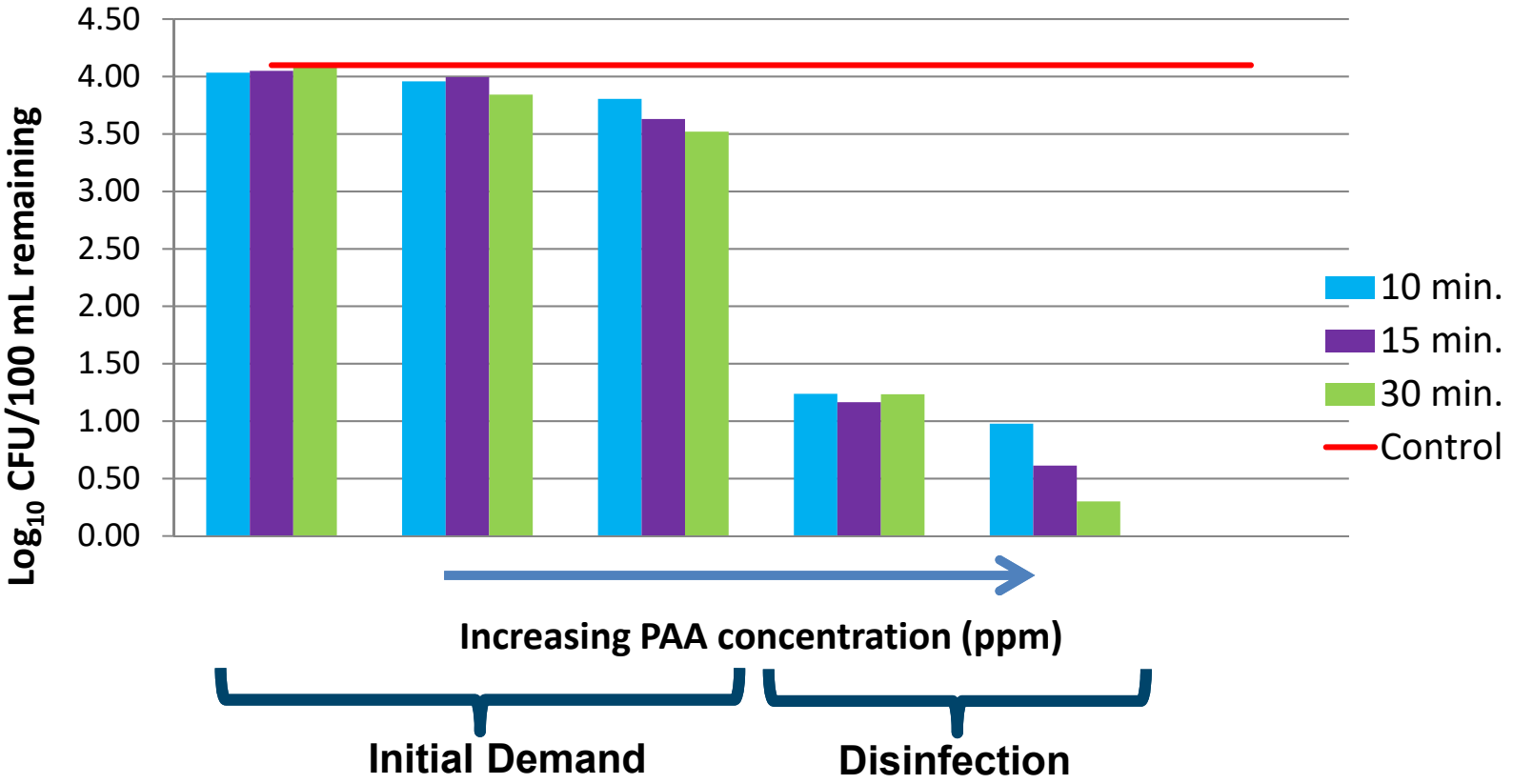
Efficacy – Demand



Significant disinfection is not observed until demand is satisfied

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Wastewater Disinfection Technology

Efficacy – Indicator Organism

Matrix	Organism	Inactivation (log)	Dose (mg/L)	Time (minutes)	Reference
Secondary effluent	Total coliform	2	1.5	20	Zanetti et al., 2007
Secondary effluent	Total coliform	2	2	16	Stampi et al. 2002
Secondary effluent	Total coliform	3	2	27	Koivunen et al,. 2005
Secondary effluent	Total coliform	4	1.5	20	Stampi et al., 2001
Secondary effluent	Total coliform	4	3	15	Madoni et al., 1998
Secondary effluent	Fecal coliform	3	2	16	Stampi et al. 2002
Secondary effluent	*E. coli*	2	1.5	20	Zanetti et al., 2007
Secondary effluent	*E. coli*	3	2	16	Stampi et al. 2002
Secondary effluent	*E. coli*	4	1.5	20	Stampi et al., 2001
Secondary effluent	*E. coli*	3	4	10	Dell'Erba et al., 2004
Secondary effluent	Enterococci	4	3	15	Madoni et al., 1998
Secondary effluent	Enterococci	2	2	16	Stampi et al. 2002
Secondary effluent	Enterococci	4	1.5	20	Stampi et al., 2001

PAA's efficacy against bacteria has been well documented

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Drivers for Conversion

Cl_2 / NaOCl Toxicity	Peracetic Acid does not require quenching
Cl_2 / NaOCl DBPs	Peracetic Acid does not produce disinfection byproducts
Cl_2 Safety	Peracetic Acid does not require a Risk Management Plan
UV Performance	Peracetic Acid effective in low UVT and peak flows
UV Capital Cost	Peracetic Acid can be a no-capital cost full service solution

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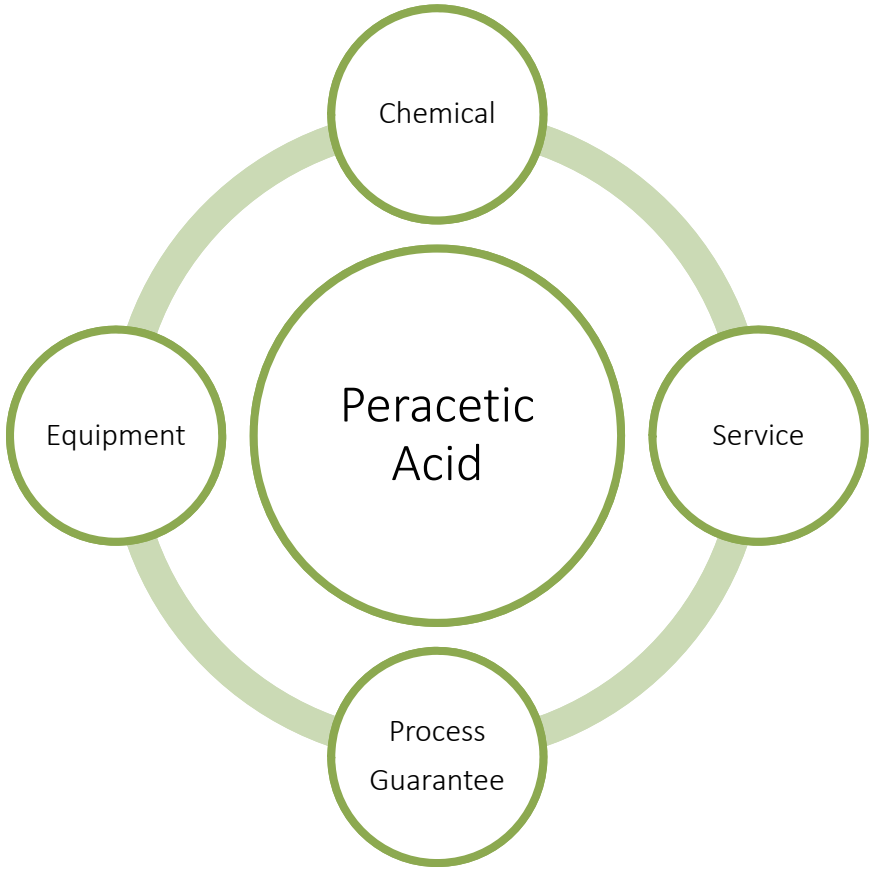
PART 3

Implementation

- Compliance
- Testing, Piloting and Trialing
- Equipment



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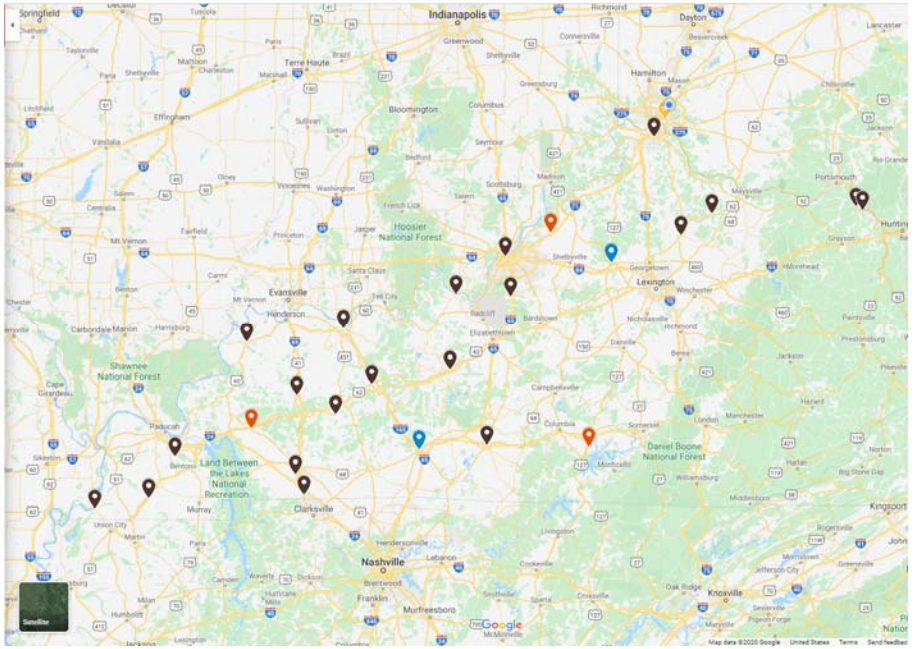
Experience in Kentucky

- Working with 22 Facilities in KY
  - (12) Chlorine (hypo & gas) replacements
  - (2) UV Replacements
  - (1) CSO Disinfection
  - (1) HRT / Wet-Weather
  - (6) UV supplementations
    - Leachate.
    - Wet-weather.
    - System Age.
- (1) Bulk Installations
- (3) Unsuccessful Pilot

- Tennessee – 6 WWTPS



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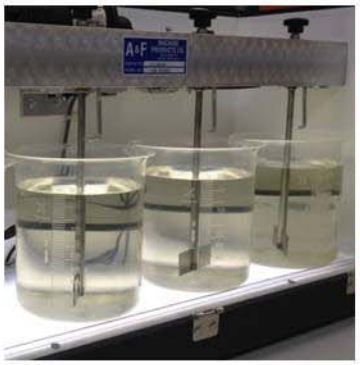
Conversion Steps



FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

Effluent Characteristic	Discharge Limitations					Monitoring Requirements	
	Storet Code	Monthly Avg.	Weekly Avg.	Monthly Avg.	Weekly Avg.	Measurement Frequency	Sample Type
Flow(MGD	50050	Report (MGD)	Report (MGD)	---	---	Continuous	Recorder
BOD_5	00310	36 lbs/day	---	30 mg/l	45 mg/l	2/month	Grab
TSS	00530	36 lbs/day	---	30 mg/l	45 mg/l	2/month	Grab
Fecal Coliform colonies/100ml	74055	---	---	200	400	2/month	Grab
pH (Standard Units)	00400	---	---	---	---	2/month	Grab
Dissolved Oxygen	00300	---	---	4 mg/l	---	2/month	Grab
Magnesium (total)	00927	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Lead (total)	01051	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Cadmium (total)	01027	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Chromium (total)	01034	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Copper (total)	01042	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Zinc (total)	01092	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Iron (total)	01045	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Nickel (total)	01067	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Silver (total)	01077	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 months	Grab
Selenium(total)	01147	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/6 month	Grab
Total Nitrogen	00600	Report (report)	---	Report (mg/l)	Report (mg/l)	1/quarter	Grab
Total Phosphorus	00665	Report (lbs/day)	---	Report (mg/l)	Report (mg/l)	1/quarter	Grab
Wetland Monitoring	---	---	---	---	---	N/A	N/A

Bench Test → Pilot → Full Scale Trial → Permit Change → Installation & Startup

Regulator

Regulator

Regulator

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Lab Testing

PeroxyChem's lab can perform disinfection kinetics bench testing on plant effluents utilizing: E. coli, Coliforms, Enterococci, MS2

Microbiology Lab in Tonawanda, NY

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Pilot Reactor Trialing

PeroxyChem's Disinfection Pilot Reactor (DPR) enables side-stream testing to measure effectiveness at different dose rates under varying effluent quality conditions.

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Cincinnati MSD – DPR Trialing 2015

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Cincinnati MSD – DPR Trialing

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Cincinnati MSD – DPR Trialing

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Cincinnati MSD – DPR Trialing

Pilot was generally successful.

Collected significant amounts of data.

MSD has moved on to several full scale pilots at other plants.

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Full Scale Trialing – KY DOW / TDEC Requirements

KY DOW

- Piloting no longer required to receive permit modification.
- Notify DOW in writing to initiate pilot.
- Do not remove / disassemble existing disinfection system.
- Will want to know how the facility is going to pump / contain the chemical.
- Generally grant up to 6 month trial. Several facilities have asked for and received extensions.
- No residual limit to date.

TDEC

- Jar Testing / Piloting Required.
- Effluent toxicity testing before and during trial
- Engineering report verifying data from the trial.
- Stream by stream analysis on acceptable residuals. Dilution factor may apply. However, typically below 1ppm.
- Test for both PAA and Peroxide residuals. Separate SAM Kits.

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Full Scale Trialing

Pilot equipment can be deployed.

Recommend 30-90 day full scale trials that enable collection of data necessary for permit change and/or cost analysis.

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Full Scale Trialing

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Pilot Setup

- Installation Supervision
- Commissioning
- Startup
- Safety Training
- Operator Training
- O&M Procedures
- Preventive Maintenance Services
- Emergency Response Services

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Equipment & Implementation

- Bulk Systems
- Tote Systems

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Implementation – Storage

Bulk Storage Considerations

- Acceptable materials include:
  - HDPE Linear (~5 yr life)
  - XLPE with OR-1000 liner. (10-12 year life)
  - Passivated SS-304L (20+years)
- Containment required (double wall acceptable)
- Product shelf life (C >15%)
  - 1 year, T < 86 ˚F
  - 4 months, T < 100 ˚F
  - 1 month, T < 110 ˚F
- Free-lift emergency relief manway and conservation vent
- Avoid overflow lines
- Unique quick connect for fill line (avoid contamination)
- Consider all local codes and regulations

Safety Considerations: containment, materials, venting, connections

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Wastewater Disinfection Technology

XLPE Tank Recommendations

From Poly Processing's Chemical Position Statement:

OR-1000 Liner – Oxidation Resistant Liner

Fitting / Bolt Material: 316SS Stainless / TEFLON Gaskets

Fittings – RHINO BOSS Fittings

1.65 SG – Tank Wall Thickness

Temperature Monitoring Strongly Recommended.

Flush water recommended.

Implementation – Storage

Tote Storage Considerations

- Containment required
- Never store on wooden pallets
- Do not store near reducing agents or combustibles (20 ft minimum distance)
- Do not block vents
- Indoor Storage
  - Ventilation of 1 $ft^3/min/ft^2$
- NFPA classification
  - Class IV Organic Peroxide
  - Does not support a flame
- Electrical
  - Intrinsically safe recommended for areas that are not well ventilated

Safety Considerations: containment, materials, venting

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Implementation – Pumps

Pump Skid Considerations

- Duty & Standby. Shelf Spare has been allowed.
- Peristaltic, Diaphragm or Solenoid acceptable
- Off-gas valve required at pump head for diaphragm and solenoid pumps
- Wetted Materials
  - Passivated 304L SS
  - Teflon
  - Santoprene™ / Norprene (peristaltic pumps)
- Controller
  - Flow-paced
  - Compound loop
- Containment Required

Safety considerations: redundancy, venting, containment, materials

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Implementation – Piping

Piping Considerations

- Compatible wetted materials of construction (Teflon / 304SS)
- Vented ball valves
- Pressure relief valves to prevent PAA entrapment
- Dilution water / Flush line
- Flex Connections for Tanks / Totes / Pumps
- Gaskets
  - GORE-TEX®
  - Teflon
  - Garlock Gylon® Style 3504
- Thread sealant
  - White Teflon Tape (Do not use anti-galling tape)
  - Fluorolube®

Safety considerations: venting, materials, flushing, flex connections

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Hand-held Residual Analyzer

Colorimetric Analyzer enables operators to measure residual in a simple and reliable way

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On-line Residual Analyzer

Amperometric,

Membrane-electrode

Submersible Probe enables automatic PAA dose control.

Third-party validated.

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On-line Residual Analyzer

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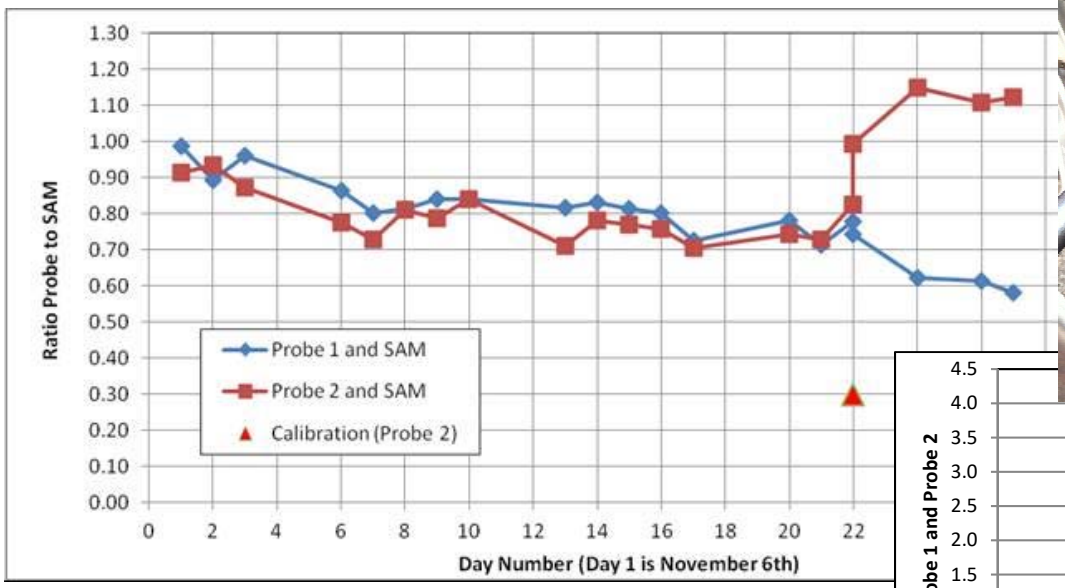
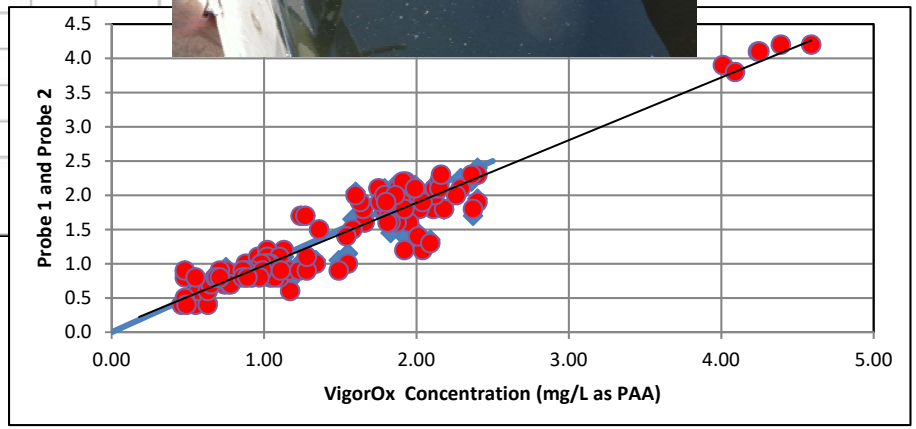
Implementation – Control





On-line residual measurement makes compound loop control possible for PAA

New generation submersible probes validated for VigorOx

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Implementation – Low Temp

Freezing Point:

- VigorOx WWT II
  -56˚F
- Sodium Hypochlorite
  -20˚F
- Sodium Bisulfate 43˚F

No heat-tracing required with PAA

Low freezing point makes PAA ideal for cold weather applications

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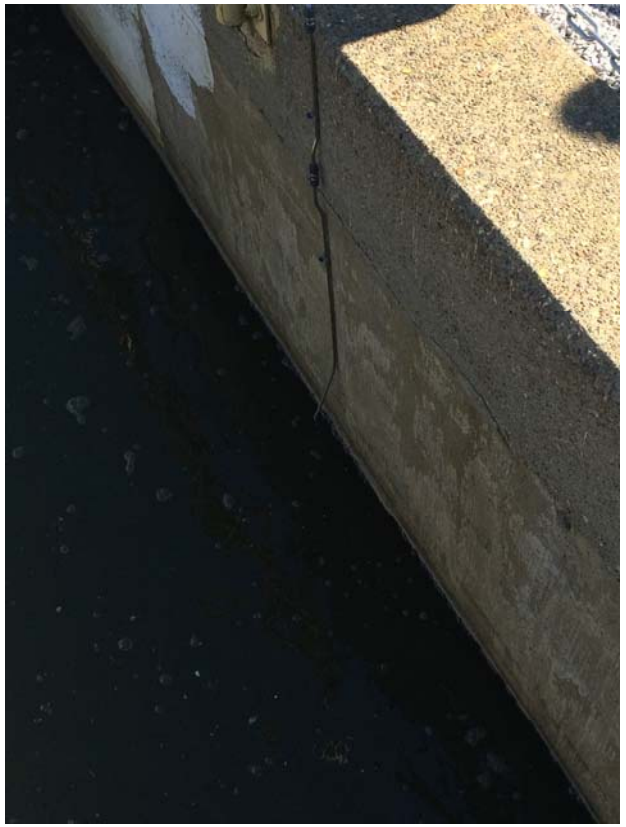
Implementation – Dosing Location

- No carrier water
- No mechanical mixing

- Typically contact basins have enough mixing energy.



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Methods of Chemical Supply

- Bulk deliveries of 4,000 gallons
- 300 gallon IBC totes
- 55 gallon drums.

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Bulk Delivery – Benefits

- Minimal Equipment handling. No moving totes or drums.
- Can be out-fitted with an auto-dialer via cellular for automatic chemical ordering
- Can be lower price per pound.
- Some chemical suppliers will provide and maintain all the equipment in their chemical supply agreement.

Memphis Production facility. From article in recent Chemical & Engineering News – 4/19/20

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Bulk Delivery – Cost Considerations

- Due to DOT requirements shipped in ISO-Tainers or “Stealth” Bulk.
- Storage Tank Cost.
- Stainless Steel Off-Loading Pump required.
- Stainless Piping
- Spill Containment or double walled tanks
- Bulk is generally cost effective at 15+ MGD ADF.

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Bulk Delivery – Alternatives

- Manifold / Daisy Chained Totes

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PART 6

Experience

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When PAA didn't work

- Too *much* contact time.
- Contact time over 2 hours has potential for regrowth of bacteria.

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When PAA didn't work

- Couldn't get dosage low enough to be cost effective vs hypo/bisulfite.

- No operator ownership of trial.
- UV Plants with minimal contact time.

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Questions? Comments?

Pelton Environmental Products
Email: JimPelton@PeltonEnv.com
Phone: 773-428-4499

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Experience in KY - Lagoons

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Experience in KY – Extended Air

- ~1 MGD facility.
- Chlorine Gas & Sodium Bisulfite.
- Large I&I problems.
  - 10:1 peaking factors

Experience in KY - Piloting

- Identified CL gas as a safety issue.
- UV was expensive due to peaking factor
- Moved forward with a 3 month peracetic acid pilot

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Experience in KY - Piloting

- Pilot began in October of 2014.
- Ran for 3 months.
  - At the time required to meet KYDOW requirements.
- Determined their effective dosage to be 1.2 -1.5 mg/l

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Experience in KY – Permanent Installation

- Submitted pilot data to KYDOW
- Granted new permit removing CL2 / SBS from permit.

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Experience in KY – Real Time Residual Monitoring

- Due the unknown permit requirements real time residual monitoring was used during pilot.

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Experience in KY – Application Point

- No additional mixing
- No carrier water
- 1 MGD * 1.2 mg/l * 8.34 / .15% = 67 lbs per day = 7 gallons per day

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Experience in KY – SBR Facility

- 7 MGD ADF / 32 MGD Peak
- SBR facility designed for UV.
- Struggled with UV maintenance issues.

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Experience in KY - Piloting

- SBR with UV design
  - Pilot tied into SCADA
  - Short Contact Time

Experience in KY - Piloting

- 12 or 24 minutes of contact time.
- Initial Demand was very high
  - Algal buildup throughout basins
- Effective dosage determined as 1.5 mg/l

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Experience in KY – Permanent Installation

- 1 tote lasts 5 days. Decided to go with bulk installation

Experience in KY – Oxidation Ditch

- 4 MGD ADF / 12 MGD Peak
- Oxidation Ditch
- 20+ year old UV failed.

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Experience in KY - Piloting

- Piloted to determine cost effectiveness.
- 2 month trial.

Experience in KY – Permanent Installation

- Effective dosage determined to be as low as .9 mg/l
- Operate around at 1.2 mg/l.

Experience in KY – Permanent Installation

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