Kemira

Performic Acid Chlorine-free Microbial Control

Kemira Water Experts

Marco Stammegna

Monitor & Control Manager,
Digital Solutions

New Ventures & Services

Kemira Water Solutions, Inc

Brett Offerman

Senior Account Manager

Urban Water

Kemira Water Solutions, Inc

SUSTAINABLE CHLORINE-FREE MICROBIAL CONTROL FOR WASTEWATER

What You Will Learn

- → Who we are
- → Alternatives to traditional methods
- → What is performic acid
- → Digital microbial control technology
- → Case studies
- → Conclusion and Q&A

Who We Are

WATER-INTENSIVE INDUSTRIES

Global Leader in Sustainable Chemical Solutions

We have:

→ Tailored products & services

→ Advanced product quality & processes

→ Alternatives to fossil-fuel based solutions

→ Energy & raw material efficiency

→ Serve a diverse range of customers

Kemira in Numbers

3.4
BILLION
REVENUE,
US DOLLAR

4,700
TOTAL EMPLOYEES
AT THE END OF
THE YEAR

OPERATING IN
36 COUNTRIES

58 MANUFACTURING SITES

SHIPPING TO
118 COUNTRIES

3 R&I CENTERS

52%
OF USED RAW
MATERIALS ARE
RENEWABLE OR
RECYCLED

5.5
TRILLION GAL
WATER TREATED
WITH KEMIRA
CHEMISTRY IN 2023

Alternatives to Traditional Microbial Control Methods

U.S. Industry Challenges

2025 *State of the Industry* report indicates:

→ 1st Priority- protection of watershed/source water from contaminants of concern

→ Pathogens & disinfection byproducts (DBPs) listed in top five contaminants of concern

- DBPs generated from chlorine-based microbial control

Top 10 Issues Facing the Water Sector as Ranked by All Respondents, 2024	
1.	Watershed/source water protection
2.	Financing for capital improvements
3.	Renewal and replacement of aging water and wastewater infrastructure
4.	Long-term water supply availability
5.	Financial sustainability
6.	Public understanding of the value of water systems and services
7.	Workforce issues
8.	Groundwater management and overuse
9.	Drought or periodic water shortages
10.	Cybersecurity issues

Contaminants of Concern Top Ranked Water Quality Concerns	
1.	Per- and polyfluoroalkyl substances (PFAS)
2.	Pathogens
3.	Lead and copper
4.	Disinfection byproducts (DBPs)
5.	Nonpoint source pollution
6.	Microplastics
7.	Cyanotoxins
8.	Nutrient removal

American Water Works Association. (2025). State of the Water Industry 2025.

Common Reasons to Switch

→ Increased chlorine cost

→ Chlorine gas storage & handling risks

→ Chlorinated carcinogenic byproducts

→ Dechlorination required

→ Updated regulatory requirements

- Decreased total residual chlorine

→ Difficulty achieving permit limits

- Treating storm event overflow

Common Reasons to Switch

Peracetic Acid (PAA)

→ Bacterial/biofilm regrowth issues

→ Slow reacting, long contact time needed

Ozone

→ Expensive compared to other methods

→ Potential formation of brominated byproducts

UV

→ Bacterial/biofilm issues

→ Difficulty achieving permit limits in wet weather

→ Water quality limitations

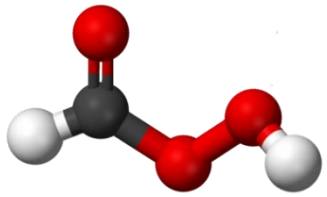
What is Performic Acid

What is Performic Acid

Equilibrium Reaction [1]

$$CH_2O_2 + H_2O_2 \rightleftharpoons CH_2O_3 + H_2O$$

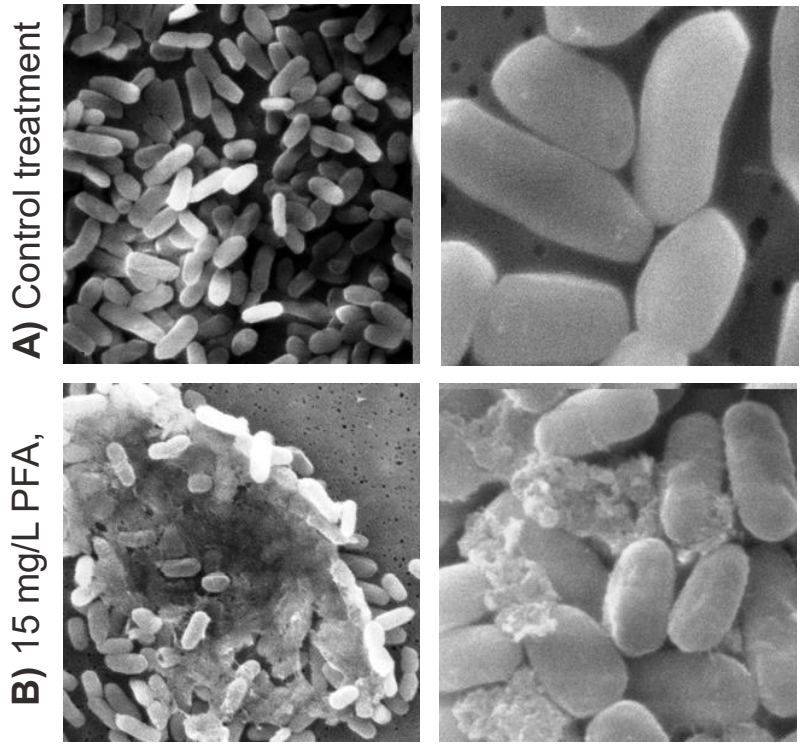
Formic Acid	Hydrogen Peroxide	Performic Acid	Water



Performic Acid

→ Non-specific oxidizer [2, 3]
→ Mechanism- releases highly reactive oxygen species [2]
→ SEM- cell wall destruction & release of cellular material [3]
→ Degrades to formic acid & H_2O [1]
→ Generated onsite (not shipped or stored) [1, 2]

SEM Images of *E. Coli* Cells



10 min contact time. Line segment: 5 µm in left images; 2 µm in right images.[3]

1. Chhetri, R.K ., et al. **2015**; Chemical Engineering Journal; 270:133-1391.
2. Karpova, T., et al. **2013**; Water Science and Technology, 68.9.
3. Veijalainen A.-M., et al. **2009** University of Kuopio Finland.

Key Benefits

RAPID MICROBIAL CONTROL

Short contact times < 10 min

Plant design flexibility

Limited containment required (microbial control & deactivation)

FAST AUTO-DECOMPOSTITION

Auto-degrades with half-life ~30 min

Quenching chemicals, sulfites, not required

EFFECTIVE AT LOW DOSES

Reduced chemical storage spatial & delivery requirements

Cost-effective & reduced risk of exposure/ spills compared to other microbicides

Dosage 3 times < PAA & chlorine

NON-TOXIC BYPRODUCTS

Carbon dioxide & water are the only byproducts

No chlorinated carcinogenic byproducts in effluent

No bacterial regrowth

COMPATIBLE WITH UV

Can be used as a secondary microbicide

Effective when treating high flows

ADAPTIVE DOSE CONTROL

Adaptive production capability

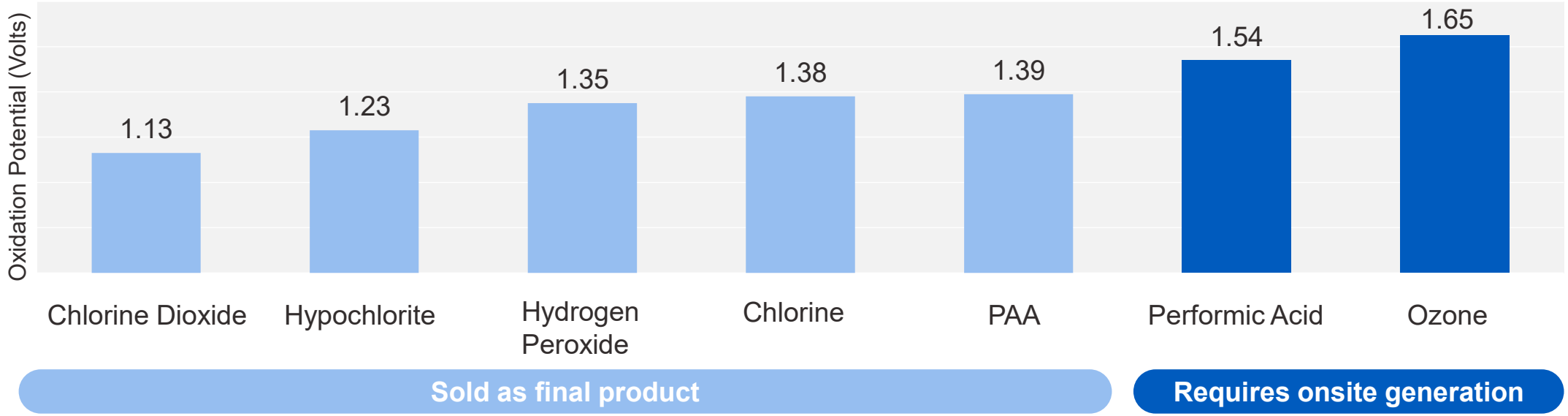
Responds quickly to variations in water quality & flow

Comparison of Microbicides

→ Redox potential indicates how well a compound can oxidize another

→ Higher redox potential > ability to oxidize organic material

→ Performic acid has > redox potential compared to most microbicides



Zhang, C.et al. **2018**; Sci Total Environ 621:948-959

Comparison of Microbicides

Performic Acid

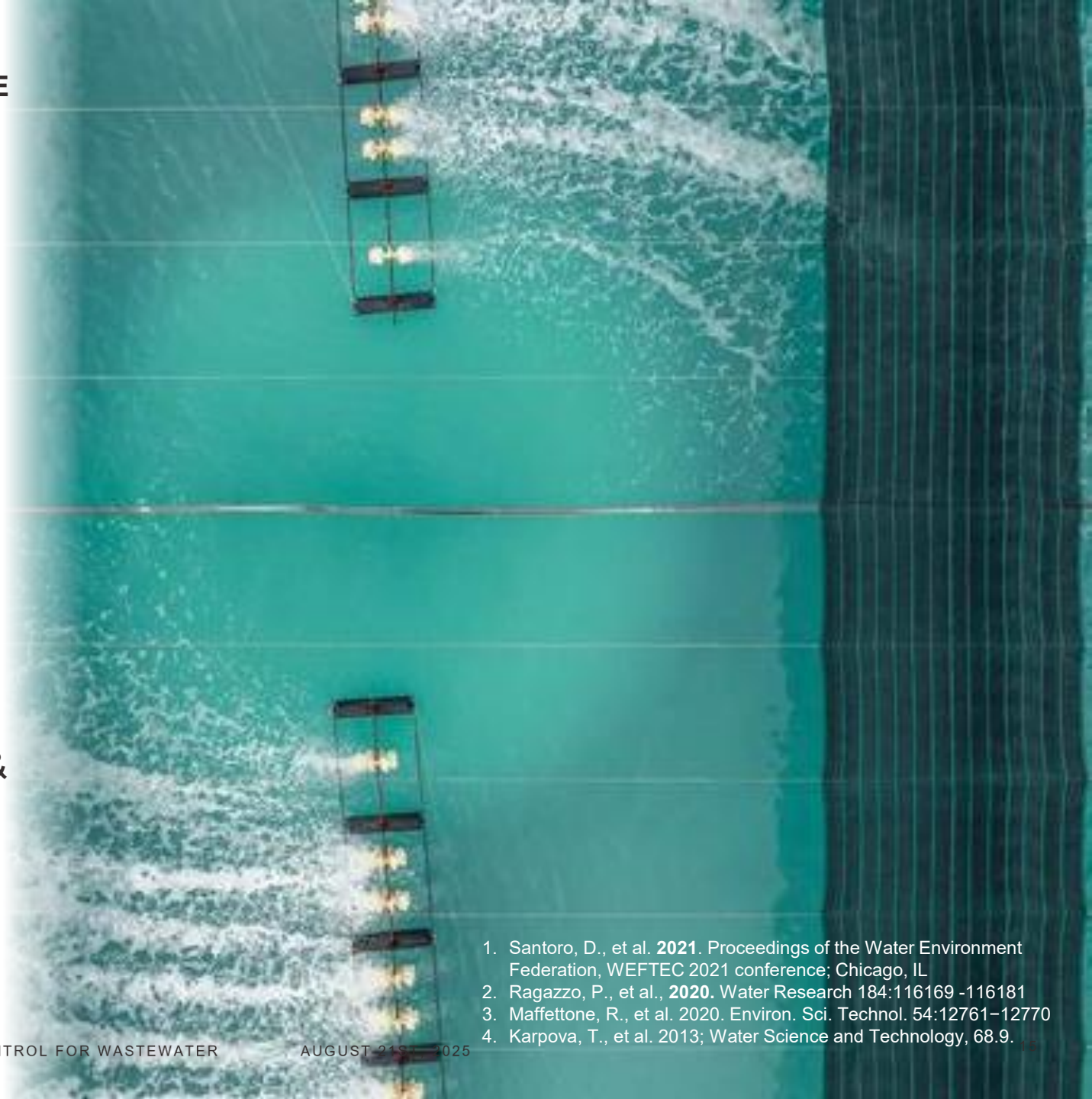
→ Higher efficacy against bacteria & viruses [1-3]

→ Faster degradation [2, 4]

→ Lower total suspended solids & pH impact [2]

→ No COD interference in secondary WW [2]

→ Requires 3 to 4 times less CT than PAA & hypochlorite [2]
(CT = concentration*contact time)



1. Santoro, D., et al. **2021**. Proceedings of the Water Environment Federation, WEFTEC 2021 conference; Chicago, IL
2. Ragazzo, P., et al., **2020.** Water Research 184:116169 -116181
3. Maffettone, R., et al. 2020. Environ. Sci. Technol. 54:12761−12770
4. Karpova, T., et al. 2013; Water Science and Technology, 68.9.

Comparison of Microbicides

Performic Acid

→ Reacted faster & required lowest ICT-dose for all tested effluents[1]

→ Counts & log inactivation graphs available for all microbes tested

→ Higher efficacy against fecal indicator bacteria at lower doses & contact times [1]

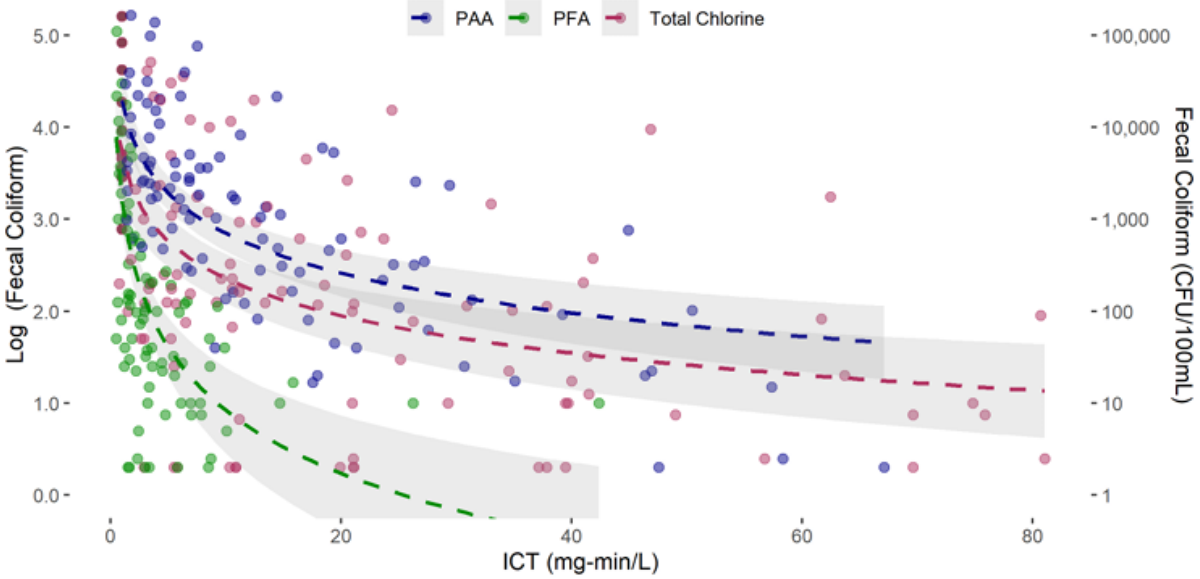


Figure 3 - Counts and Log Inactivation: *Fecal Coliform*

Performic acid had a faster decline in fecal coliform as a function of Integrated Contact Time (ICT) = Dose x Time (min).[2]

1. Tikariha L., et al. 2025. J Environ Manage. 124711.
2. Santoro, D., et al. **2021**. Proceedings of the Water Environment Federation, WEFTEC 2021 conference; Chicago, IL

Comparison of Microbicides

During microbial control of standard WW

→ Performic acid & PAA produced fewer byproducts than chlorine[1]

→ Performic acid formed no toxic byproducts [2]

During microbial control of saline WW

→ PAA produced more brominated & iodinated byproducts than chlorine[1]

→ Performic acid produced none of the tested halide (bromine, iodine) byproducts[1]

1. Wang, J. et al. 2023 *57* (47), 18898-18908
2. Karpova, T., et al. **2013;** Water Science and Technology; 68:2090-2096

Digital Microbial Control

Generation Unit

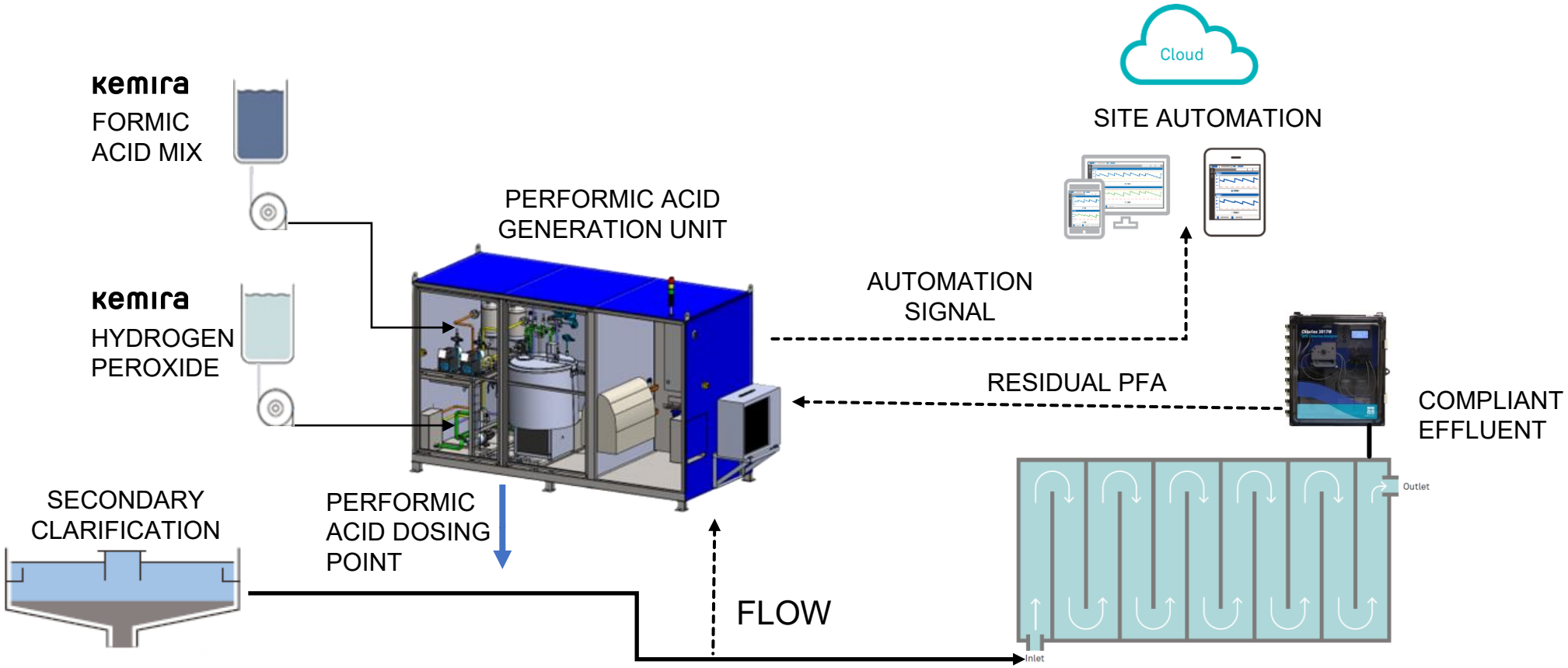
Production is flexible
- → 1- 200 MGD microbial control capacity
- → Monitors flow rates
- → Online residual performic monitoring
- → Scalable for seasonal bacteria limits
- → Redundancy capacity

Intelligent dose control
- → Based on residual performic acid & WW flow

Adaptive production
- → Responds to load variations
  - Average vs. wet weather flows
  - Water quality changes – mixing primary treated WW w/ secondary

Relevant U.S. Patent No. 11,925,914 B2

Digital Microbial Control



Relevant U.S. Published Patent Application No. 2025/0197248 A1

N, N-DIETHYL-P-PHENYLENEDIAMINE (DPD) METHOD

→ Manual measurement of performic acid

→ Developers- Kemira, AquaPhoenix & CDM Smith

→ Published in Standard Methods book & online

→ “4500-PAA PFA Peracetic & Performic Acid” (Residual)

United States Case Studies

kemira

CHLORINE-FREE MICROBIAL CONTROL FOR WASTEWATER

AUGUST 21ST , 2025

PILOT STUDY, GRESHAM, OREGON

GRESHAM WWTP

13

MGD

Activated Sludge

Performic Acid Pilot Study

→ Evaluation of efficacy & toxicity at laboratory & pilot scale

→ Lab & pilot results achieved National Pollutant Discharge Elimination System permit (NPDES) limits

→ Performed in partnership with Jacobs Engineering

Porat, I., et al. 2023. Proceedings of the 96th Annual Water Environment Federation Technical Exhibition and Conference [on-line], Chicago, IL, United States.

Results

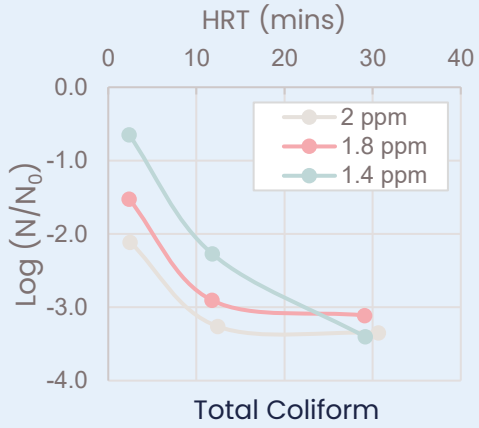
→ Treated secondary WW met NPDES *E. coli* limits

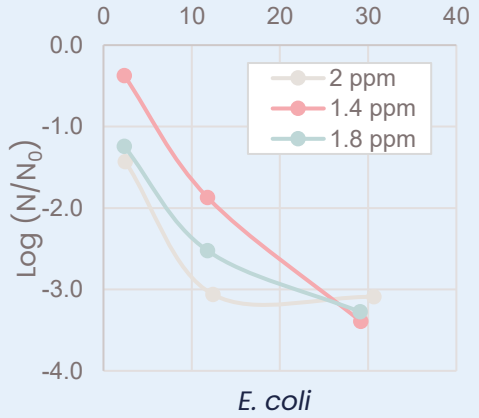
→ No quenching anticipated based upon

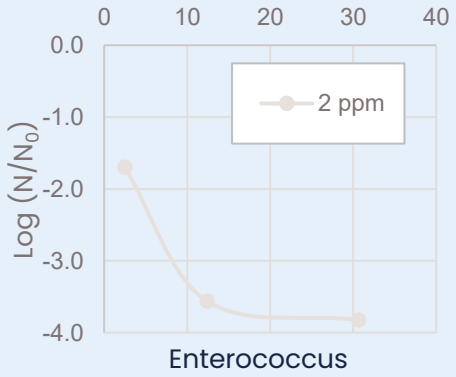
- Toxicity data & low residual performic acid

→ WET tests showed compliance with effluent limits

- 4 mg/L dose at 15 min contact time







Porat, I., et al. 2023. Proceedings of the 96th Annual Water Environment Federation Technical Exhibition and Conference [on-line], Chicago, IL, United States.

CAPITAL REGION WASTEWATER (CRW)

21 MGD

Activated Sludge

Performic Acid Pilot Study

→ Evaluation of efficacy & toxicity at laboratory & pilot scale (secondary WW)

→ Evaluation of efficacy during stormwater events (primary WW mixed with secondary)

Porat, I., et al. 2024. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States.

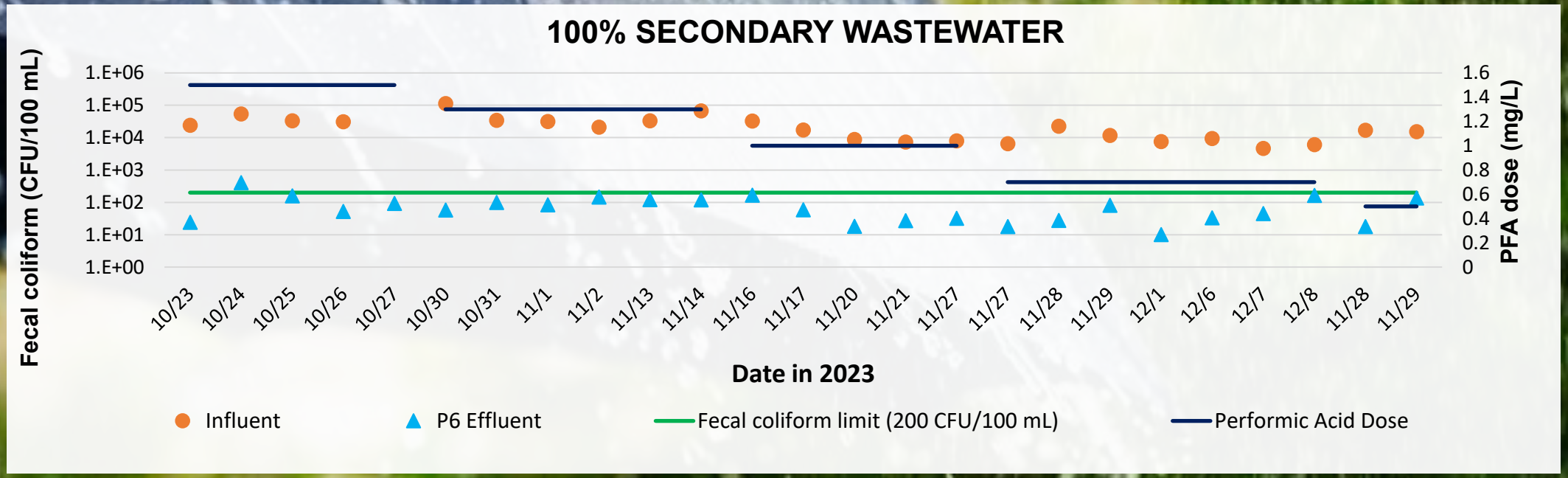
Performic Acid Pilot Installation

→ 100% secondary WW, primary/secondary WW mixes
→ Fixed performic acid doses & doses regulated by residual

Porat, I., et al. 2024. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States.

FIXED DOSE, MAINTAINED FECAL COLIFORM (FC) BELOW LIMIT

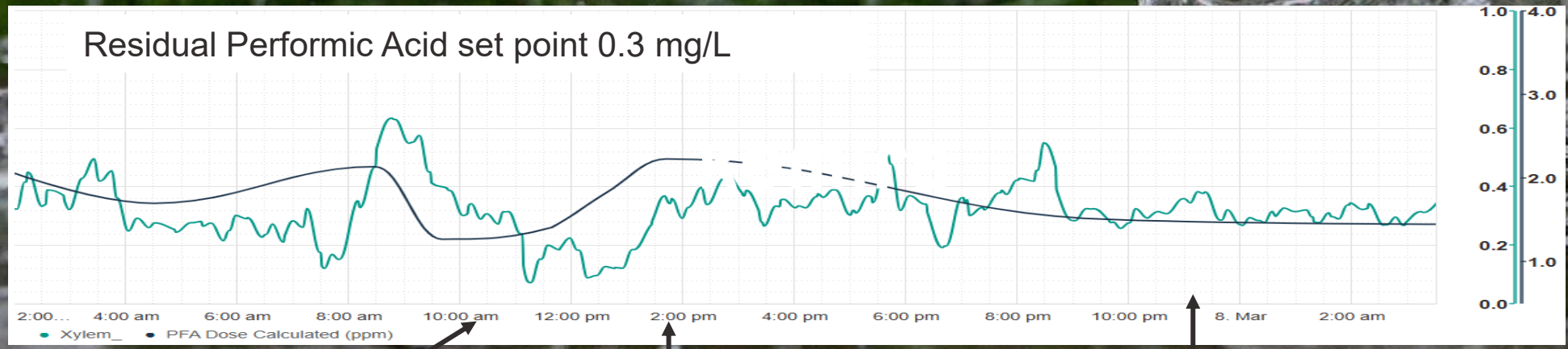
Fixed Performic Acid Dose



Porat, I., et al. 2024. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States.

Residual Performic Acid- Adjustable Dose

Relevant U.S. Published Patent Application No. 2025/0197248 A1



10:30 am sample
9% primary blending
FC = 5 CFU/100 mL

2:00 pm sample
20% primary blending
FC = 14 CFU/100 mL

Residual PFA stabilized 0.3 mg/L;
PFA dose stabilized at 1.5 mg/L

Porat, I., et al. 2024. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States.

Results

- → Effective at low dose with short contact time
- → No quenching of residual required
- → Non-toxic residual concentration 0.42 mg/L
- → Maintained residual below toxicity by adjusting dose
- → Effective during storm events

Porat, I., et al. 2024. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States.

European Installations

Performic Acid Installations

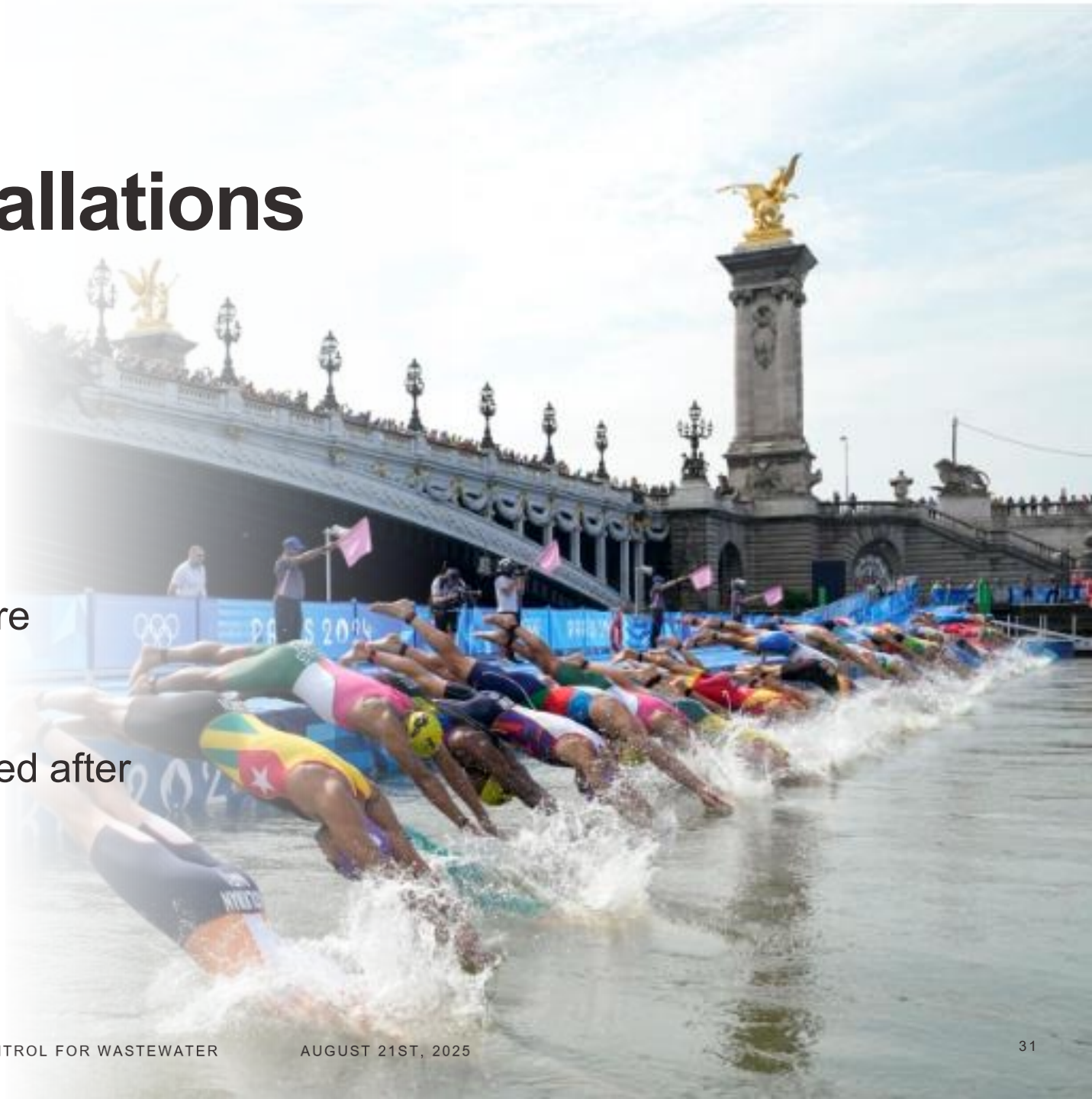
Used in nine European countries

→ 18 Municipal WW treatment plants

→ 20 Industrial manufacturing facilities

Used in Paris, France to treat WW before discharge into the river Seine for 2024 Olympic games

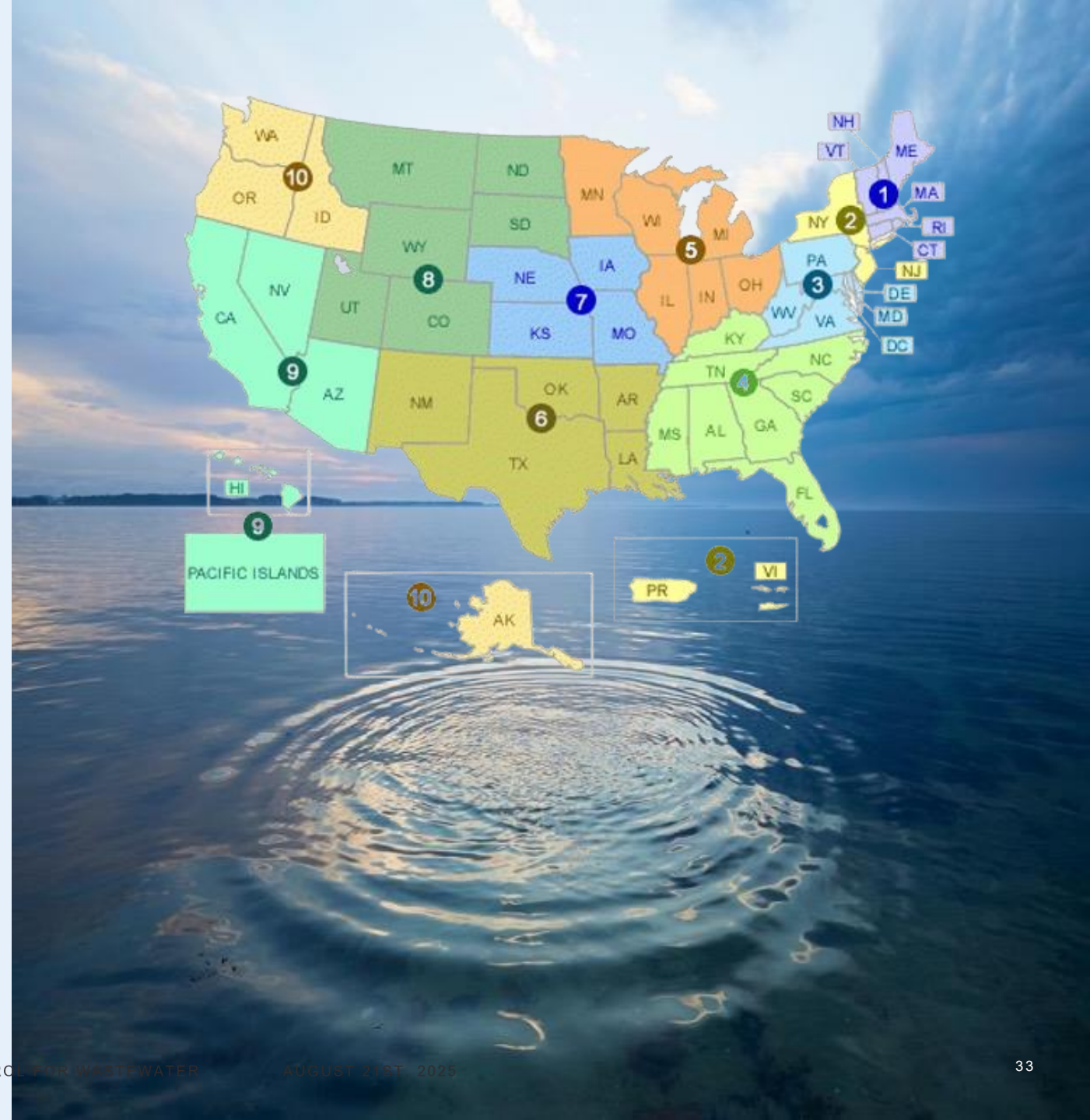
Siene public swimming recently reopened after 1923 ban repealed



Concluding Remarks

U.S. Certifications

- → **Federal Registration**
  - → EPA Reg. No. 9386-5, Fennosurf 600, mixed acid precursor
- → **State Registrations**
  - → In process (mixed acid precursor)
- → **US Patent**
  - → No.11,925,914 B2
- → **US Patent Application**
  - → No. 2025/0197248 A1



PERFORMIC ACID PRECURSOR

Regulatory Statement

Regulatory Note: All pesticides being sold or distributed in the United States must be registered with the US Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) along with each individual state and US territory. FennoSurf 600 (Precursor for the Generation of Performic Acid) has been approved by the EPA (EPA Reg. 9386-51) as of May 5th, 2025. US state registrations for Fennosurf 600 are in progress and must be confirmed prior to any offer for sale. Pesticides being sold or distributed in Canada, must be registered with Health Canada's Pesticide Management Regulatory Agency (PMRA) under the Pest Control Products Act (PCPA). Canadian registration is in progress for FennoSurf 600. All performic acid-based products marketed or sold under the KemConnect® DEX, Fennosurf or other tradenames in the USA - for use in wastewater effluent treatment systems - are intended for non-public health microbial control. Any historical or non-US references using terminology other than "microbial control or microbicide" - made by Kemira Water Solutions, Inc. or third parties - does not constitute as an EPA approved claim nor does it apply to Kemira's EPA registered pesticides intended for use in wastewater effluent microbial control.

Conclusion

RAPID MICROBIAL CONTROL Short contact times < 10 min Plant design flexibility Limited containment required (microbial control & deactivation)	**FAST AUTO-DECOMPOSTITION** Auto-degrades with half-life ~30 min Quenching chemicals, sulfites, not required	**EFFECTIVE AT LOW DOSES** Reduced chemical storage spatial & delivery requirements Cost-effective & reduced risk of exposure/ spills compared to other microbicides Dosage 3 times < PAA & chlorine
NON-TOXIC BYPRODUCTS Carbon dioxide & water are the only byproducts No chlorinated carcinogenic byproducts in effluent No bacterial regrowth	**COMPATIBLE WITH UV** Can be used as a secondary microbicide Effective when treating high flows	**ADAPTIVE DOSE CONTROL** Adaptive production capability Responds quickly to variations in water quality & flow

Join Us in Chicago!

Kemira Water Solutions, Inc.
Booth # 426

Thank You for Listening
Time for Q&A

For more information, please contact
Brett.Offerman@kemira.com
Marco.Stammegna@kemira.com

kemira

References

References

American Water Works Association. (2025). State of the Water Industry 2025- Executive Summary. SOTWI_ES_2025_WEB

Aubeuf-Prieur, P., Porat, I. Stammegna, M., Greus, S. (2024). Performic Acid Production Systems and Methods (US 11,925,914 B2). United States Patent and Trademark Office. US-11925914-B2 - Patent Public Search | USPTO

Chhetri, R.K.; Flagstad, R., Munch, E.S., Horning, C., Berner, J., Kolte-Olsen, A., Thornberg, D., Andersen, H.R. (2015). Full Scale Evaluation of Combined Sewer Overflows Disinfection Using Performic Acid in a Sea-outfall Pipe; Chemical Engineering Journal; 270, 133-139.

EPA Reg. No. 9386-5, FennoSurf 600, Kemira Chemicals Inc.(2025).

Karpova, T., Pekonen, P., Gramstad, R., Öjstedt, U., Laborda, S., Heinonen-Tanski, H., Chavez, A., Jiménez, B. (2013). Performic Acid for Advanced Wastewater Disinfection. Water Science and Technology, 68(9), 2090-2096.

References

Maffettone, R., Manoli, K., Santoro, D., Passalacqua, KD., Wobus, CE., and Sarathy, S. (2020). Performic Acid Disinfection of Municipal Secondary Effluent Wastewater: Inactivation of Murine Norovirus, Fecal Coliforms, and Enterococci; Environ. Sci. Technol. 54:12761−12770

Porat, I., Stammegna, M., Hill, C., Reina, J., Registe, J., Noesen, M. (2023, Sept 30 - Oct 4). Performic Acid Testing For Evaluation of Disinfection Efficacy And Toxicity in WWTP Secondary Effluent at Both Laboratory and Onsite Pilot Demonstration. Proceedings of the 96th Annual Water Environment Federation Technical Exhibition and Conference [on-line], Chicago, IL, United States. Water Environment Federation.

Porat, I., Stammegna, M., Hill, C., Skold, I., Hansen, J., Hoke, R., Hart, B., Rosentel, J. (2024, Oct 5- 9). Performic Acid Disinfection at Capital Region Water - Including Stormwater Events. Proceedings of the 97th Annual Water Environment Federation Technical Exhibition and Conference [on-line], New Orleans, LA, United States. Water Environment Federation.

References

Ragazzo, P; Chiucchini, N; Piccolo, V; Spadolini, M; Carrer, S; Zanon, F; and Gehr, R (2020).Wastewater Dusunfection: Long-term Laboratory and Full-scale Studies on Performic Acid in Comparison with Peracetic Acid and Chlorine. Water Research 184:116169 -116181.

Rocher, V., Azimi, S. (2021). Effectiveness of disinfecting wastewater treatment plant discharges. Case of Chemical Disinfection Using Performic Acid. IWA Publishing, London, United Kingdom.

Santoro, D.: Registe, J.; Hilts, B.; Walton, J.; El-Halway, M.; Maffettone R., and Kyriakos, M. (2021, Oct 16-20). Advancement in Peracids Disinfection of Municipal Wastewater: Approaching the Economics of Sodium Hypochlorite with Performic Acid and Advanced Process Control. Proceedings of the 94th Annual Water Environment Federation Technical Exhibition and Conference [on-line], Chicago, IL, United States. Water Environment Federation.

Stammegna, M., Porat, I. (2025). Water Treatment System (US 2025/0197248 A1). United States Patent and Trademark Office. US-20250197248-A1 - Patent Public Search | USPTO

References

Tikariha L, Manoli K, Lawryshyn Y, Norton JW, da Silva AK, Bell K, Jang E, Santoro D. (2025). A Comparative Evaluation of Performic Acid, Peracetic Acid, and Sodium Hypochlorite for Bacterial Disinfection of Secondary Effluent. J Environ Manage. 124711.

Veijalainen A.-M, Heinonen-Tanski H., Naarala J. and Atalay M. (2009). University of Kuopio Finland, internal report

Wang, J; Xu, J; Kim J; and Huang, C-H (2023). Mechanistic Insight for Disinfection Byproduct Formation Potential of Peracetic Acid and Performic Acid in Halide-Containing Water Environmental Science & Technology 57:18898-18908

Zhang, C., Brown, P.J.B., Hu, Z. (2018). Thermodynamic Properties Of An Emerging Chemical Disinfectant, Peracetic Acid. Science of the Total Environment, 621, 948-959.

4500-PAA PFA Peracetic and Performic Acid (Residual): Standard Methods For the Examination of Water and Wastewater. DOI: 10.2105/SMWW.2882.220.