

Emerging disinfection technologies for water and wastewater treatment



WEBINAR

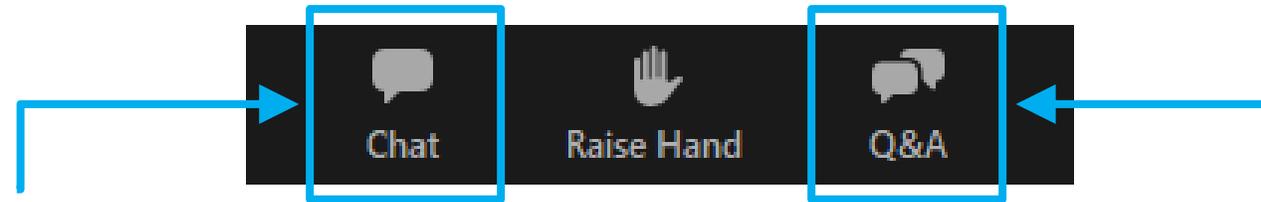
7 December 2022 | 12:00 GMT
iwa-network.org/webinars

WEBINAR INFORMATION



- This webinar will be **recorded and made available “on-demand”** on the IWA website, with presentation slides, and other information.
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WEBINAR INFORMATION



- **'Chat' box:** please use this for general requests and for interactive activities.
- **'Q&A' box:** please use this to send questions to the panelists. (We will answer these during the discussions)

Please Note: Attendees' microphones are muted. We cannot respond to 'Raise Hand'.

IWA DISINFECTION SG



International Water Association

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Specialist group
Disinfection

Timeline Group members Pages Documents

About: Specialist group Show more

Welcome to SG of Disinfection!
Disinfection is among the Top 10 human technical progress which has saved millions of people from epidemic!
Chao Chen

Share an update or ask a question

Rachna Sarkari in Disinfection
last Monday at 11:33 AM
The future of disinfection in drinking water & wastewater

Rachna Sarkari in IWA Events
last Monday at 11:30 AM

Group committee
9 Group committee

Group members
1844 members

Calendar
No events
+ New event

Documents
Disinfection Constitution_Mar...
16 May 2019 - 00:00
Summary of submissions.docx
8 March 2018 - 00:00

The Disinfection Specialist group aims to create, exchange and transfer the knowledge and experience of disinfection-related issues in water, wastewater, sludge or excreta.

Join the IWA DISINFECTION SG on IWA Connect!

<https://iwa-connect.org/group/health-related-water-microbiology/timeline>

Poll

MODERATOR: LUDWIG DINKLOH

AGENDA

- Welcome, housekeeping rules, introduction & Poll 1
Ludwig Dinkloh, IWA Disinfection SG
- Is a Transition to UV-C LED Disinfection Technology in Municipal Applications Viable?
Galina Shevyrina, Aquisense
- Electrical Pulse Oxidation Process (EPOP) – An alternative AOP Treatment for the Decomposition of Micro-Pollutant and Disinfection of Wastewater
Oren Gafri, WADIS
- Recent advances and scale up challenges in oxidants production by electrochemical processes for water disinfection
Prof. Engracia Lacasa, University of Castilla-la-Mancha
- Locally Enhanced Electric Field Treatment (LEEFT)
Prof. Jianfeng Zhou, Georgia Tech Shenzhen Institute
- Poll 2, final remarks and conclusion
Emmanuel Mousset, IWA Disinfection SG



Emmanuel Mousset
(Moderator)



Ludwig Dinkloh
(Moderator)



Jianfeng Zhou
(Speaker)



Oren Gafri
(Speaker)



Galina Shevyrina
(Speaker)



Engracia Lacasa
(Speaker)



Is a Transition to UV-C LED Disinfection Technology in Municipal Applications Viable?

GALINA SHEVYRINA, AQUISENSE TECHNOLOGIES



AquiSense Company Overview



COMPANY OVERVIEW

AquiSense exists to protect human health

Pearl products use Ultraviolet LEDs to disinfect without harmful chemicals or heavy metals
Our goal is to provide OEM products that are not just better, but vastly better than existing solutions



Research



OEM



Residential



Municipal/Industrial

- Founded in 2015. Two acquisitions completed
- Over 50 employees. 3 PhD & 20 graduate engineers.
- Manufacturing in USA. Offices in UK, Germany, India & Japan

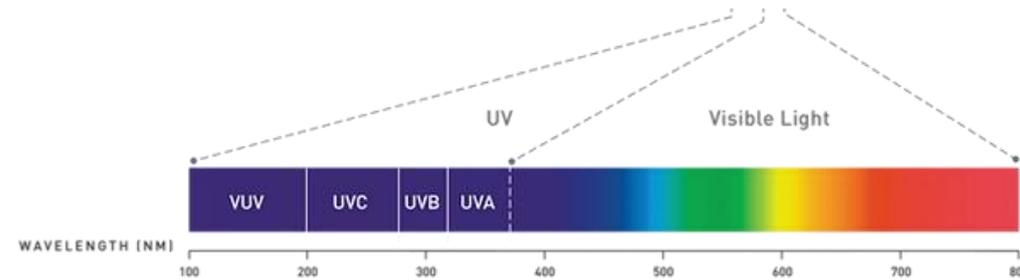


Technology Overview

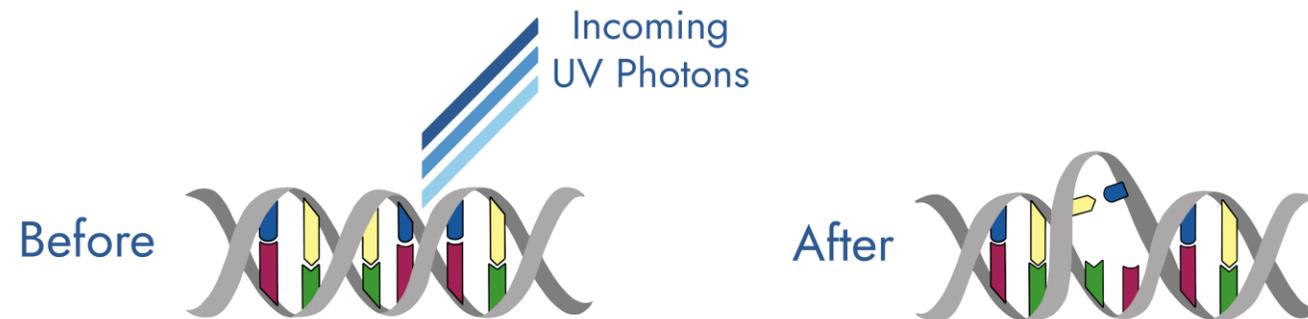


WHAT IS ULTRAVIOLET LIGHT?

UV light - between visible light and x-ray on the electromagnetic spectrum



UV-C photons penetrate organic cells and damage their DNA, rendering them incapable of reproduction (microbiologically inactive)

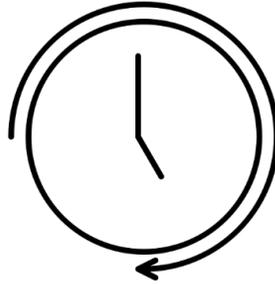


LIMITATIONS OF TRADITIONAL UV TECHNOLOGY



Materials

- Mercury
- Quartz



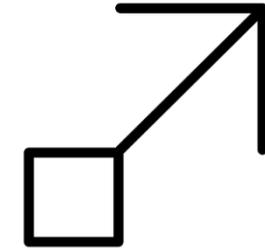
Operation

- Warm-up time
- Limited on/off cycles



Durability

- Fragile quartz tube



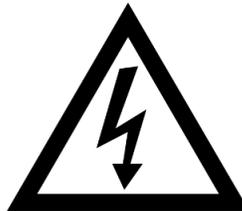
Footprint

- Low power density
- Large ancillaries



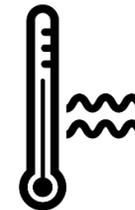
Weight

- Reactor
- Electronics



Power

- AC Mains Voltage only



Temperature

- 100-600°C impacts process fluid



Wavelength Compromise

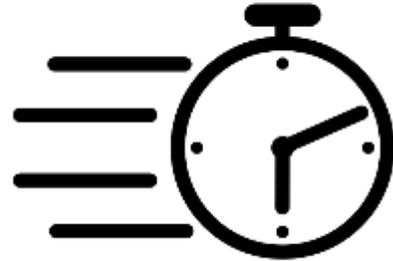
- LP: 254nm
- MP: 200-300nm

POTENTIAL IMPROVEMENTS WITH UV LEDs



Materials

- Mercury-free



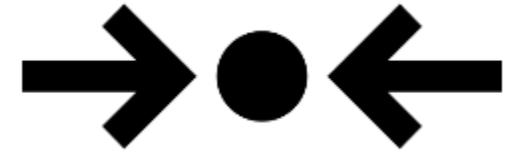
Operation

- Instant on/off
- Unlimited on/off cycles



Durability

- Robust design



Footprint

- High power density
- Compact size



Weight

- Light-weight
- Reduced parts list



Power

- Flexible power options



Temperature

- No heat transfer



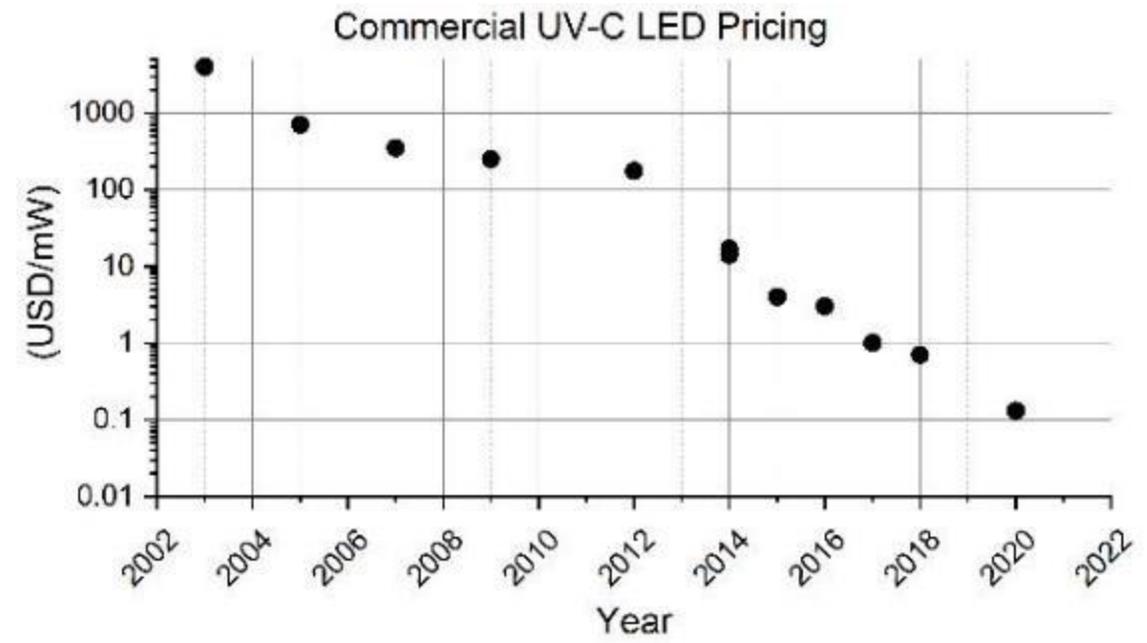
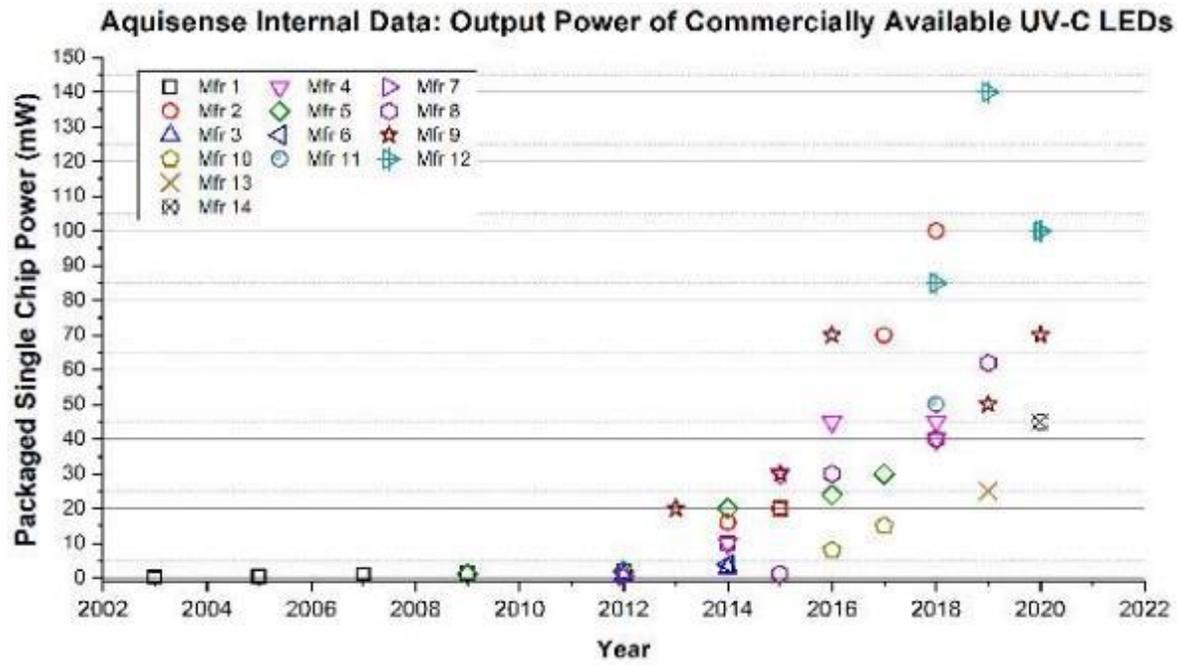
Wavelength Compromise

- Flexible wavelengths based on needs

UV LED Commercialization



UV LED TECHNOLOGY AND COST EVOLUTION

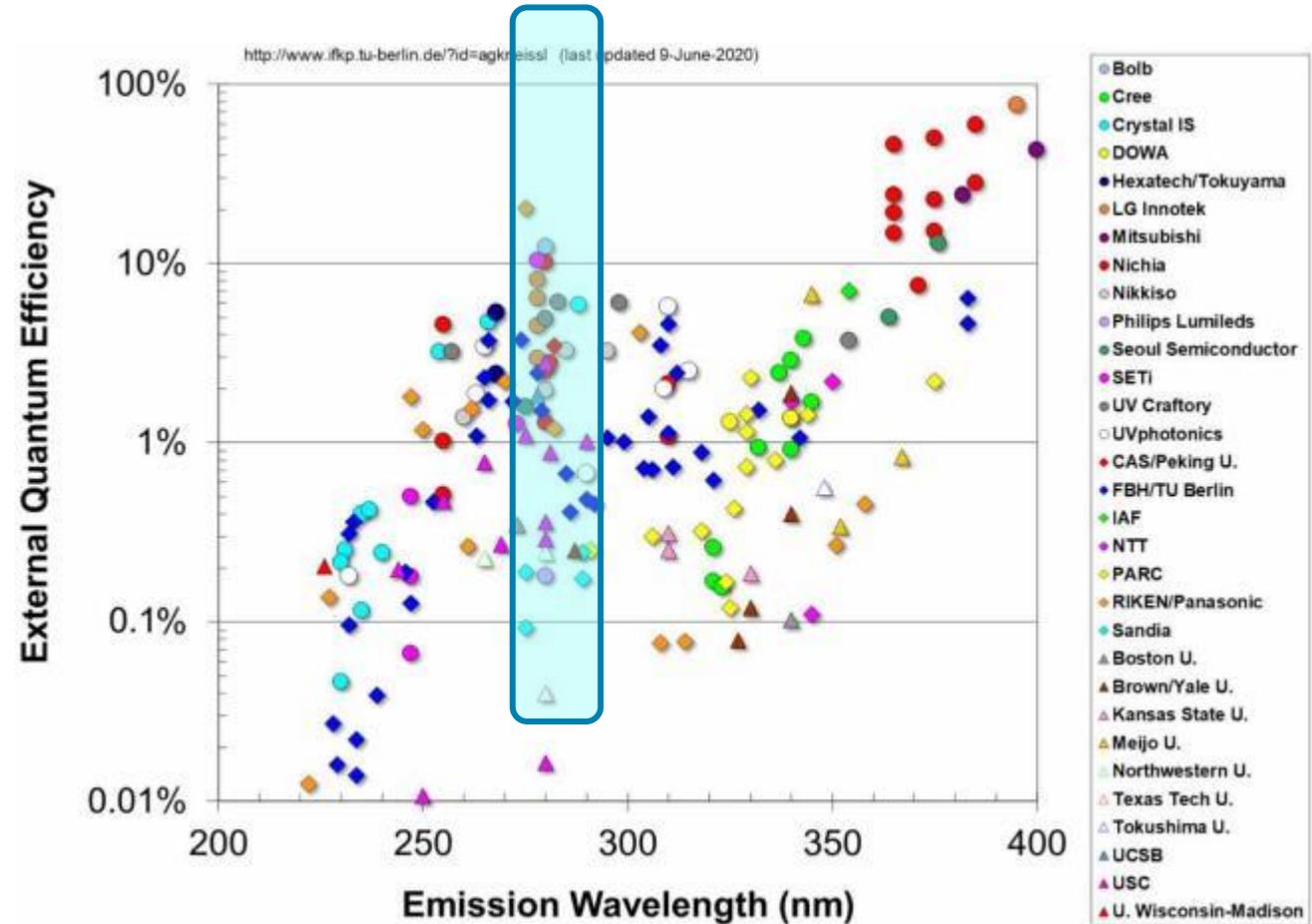


Source: Internal Aquisense Data

UV-C LED DEVELOPMENT

Haitz's Law: Optical output increases x20, and price/output decrease x10, per decade

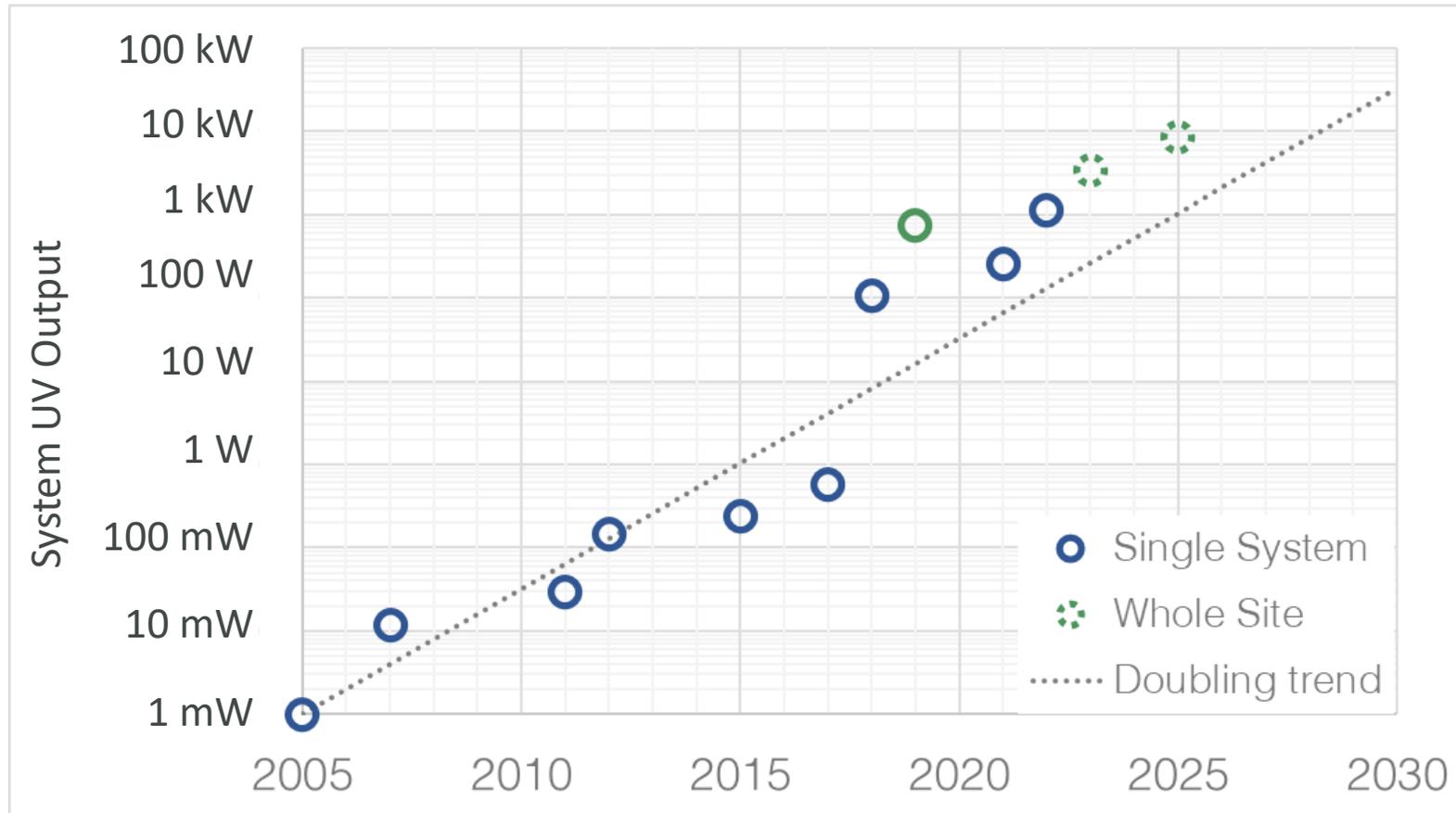
- External Quantum Efficiency
 - $\frac{\text{Optical Power Out}}{\text{Electrical Power In}}$
 - Widely-used development metric
- Physics-driven features
 - 365 nm boundary
 - General decrease with shorter wavelength
- Market-driven features
 - Trough in UV-B range
 - Peak about 280 nm



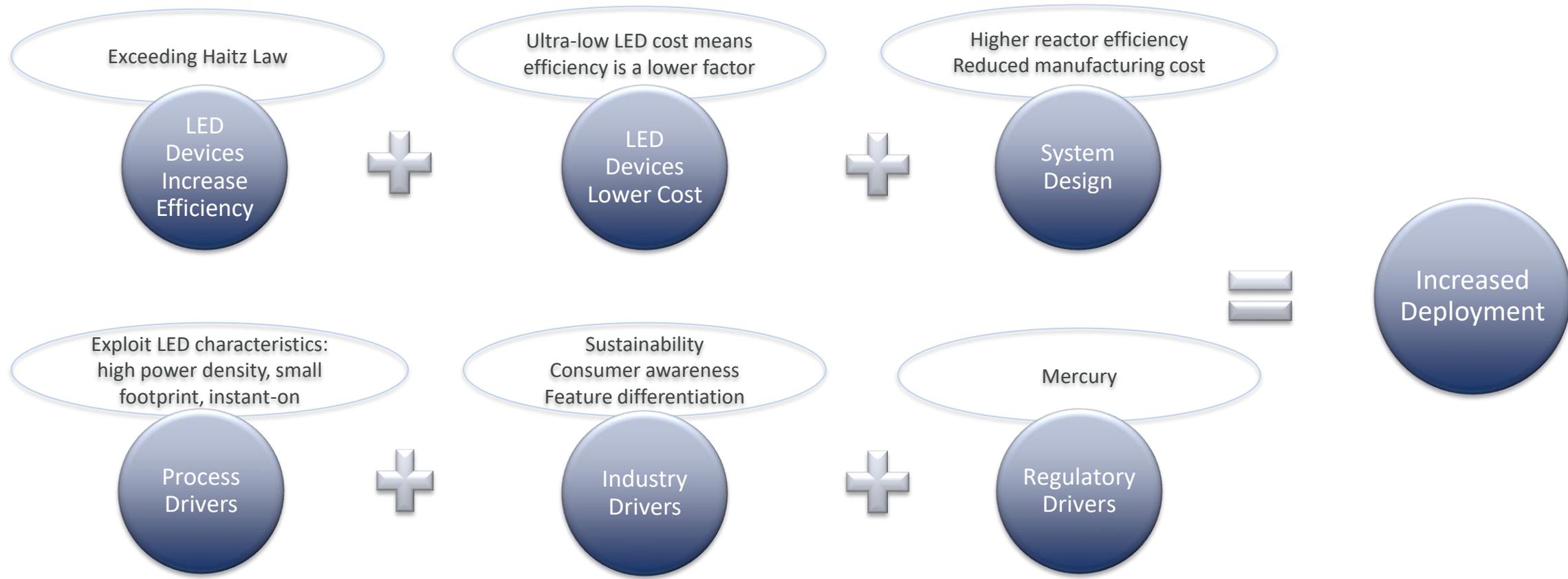
Amano et al 2020 J. Phys. D: Appl. Phys. 53 503001

SINGLE-SYSTEM MAX. UV OUTPUT POWER

LED maturity (not just power) has facilitated ~6-log growth in assembled system power since first commercialisation – 139% CAGR

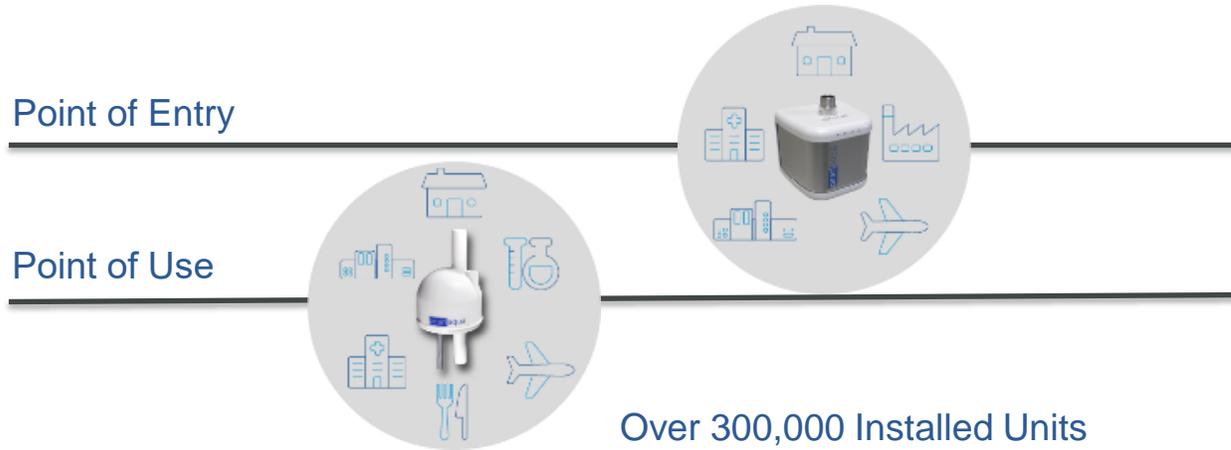


UV-C LED COMMERCIALIZATION



UV LEDS STARTING TO DOMINATE LOW FLOW APPLICATIONS

- UV LED technology creates new applications
- Leading global brands are integrating UV LEDs
- Successful integration in wide range of markets



UV LED System Product Platforms



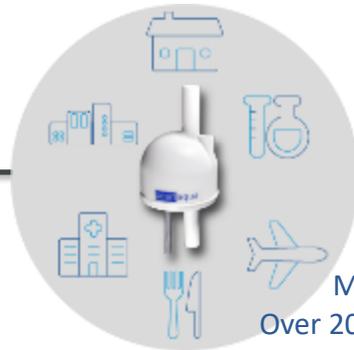
WATER TREATMENT PRODUCT PLATFORMS

Municipal

Industrial

Point of Entry

Point of Use



Launched in 2018
Multiple Configurations
Over 20,000 produced each month



World's First UV-C LED POE System



Pilot Early 2023



Flow Rate:

3 gpm

50 gpm

1 mgd+

PEARLAQUA TERA

- Replaceable UV-C LED lamp array
- Instant on/off and variable power delivery according to demand
- On-line UV Intensity Monitoring
- Stable cooling design for safe operation and maximum lamp life
- Compact and simple design for ease of installation and maintenance



Lamp Array

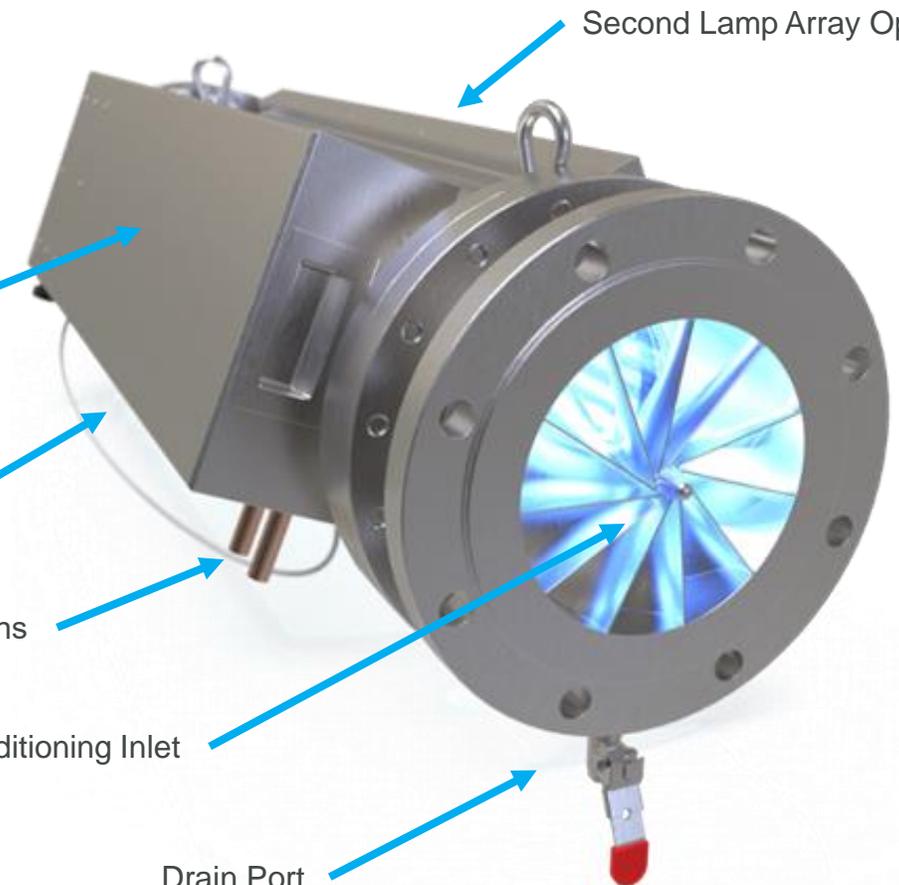
DVGW Online UV Intensity Sensor

Coolant Connections

Flow Conditioning Inlet

Drain Port

Second Lamp Array Option



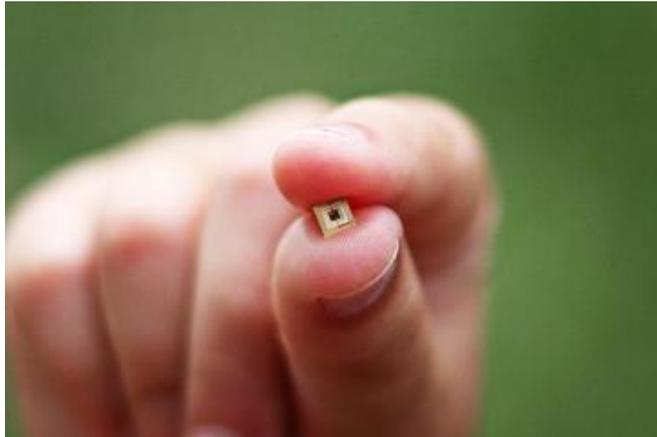
FIRST INSTALLATION – LAS VEGAS, USA

DECEMBER 2021



Planned Installations in coming 6 months

- 5 units South-West, USA. Municipal Water Treatment
- 1 unit South-West, USA. Reuse Water
- 2 units West coast USA. Disinfection and & AOP Pilot
- 1 unit Canada. Municipal Water Treatment
- 2 units South America. Downhole injection, Oil & Gas



Galina Shevyrina

Application Engineer, AquiSense Europe

Galina.Shevyrina@AquiSense.com

Electrical Pulse Oxidation Process (EPOP) – An alternative AOP Treatment for the Decomposition of Micro-Pollutant and Disinfection of Wastewater

OREN GAFRI, WADIS LTD



WADIS EPOP TECHNOLOGY



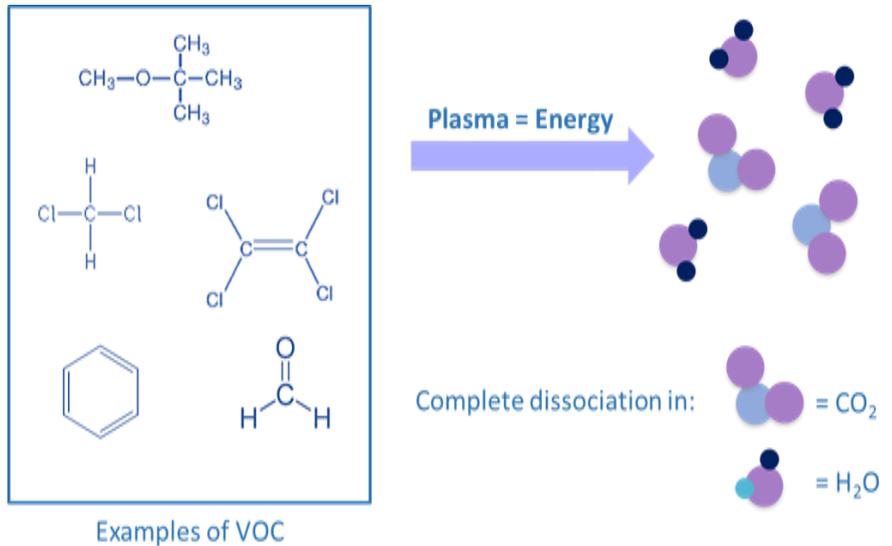
The process uses high-voltage electrical pulses at a high frequency directly in the effluent, through a multi - electrodes reactor with a carrier gas, generating plasma in the wastewater for the decomposition of the organic pollutants and disinfection.

The process works using two combined phenomena:

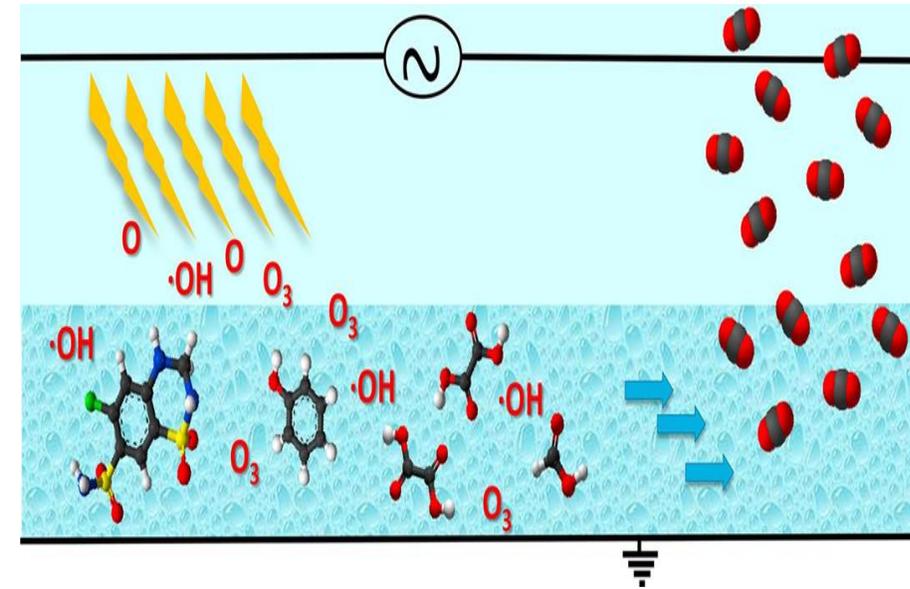
- The plasma decomposes the APIs by high temperature (Thousands of degrees locally), and UV which are generated at the discharge canal, in addition to high electrical and magnetic fields
- The plasma with a carrier gas (such as Air or Oxygen) produces reactive radicals (such as hydroxyl radicals, oxygen radicals, hydrogen peroxide, and ozone) which assist in the decomposition of the pollutants

The EPOP process also disinfects wastewater from all types of microorganisms.

WADIS EPOP API DECOMPOSITION PROCESS IS MADE IN TWO COMBINED STAGES:



- Stage 1 – Decomposition by the plasma



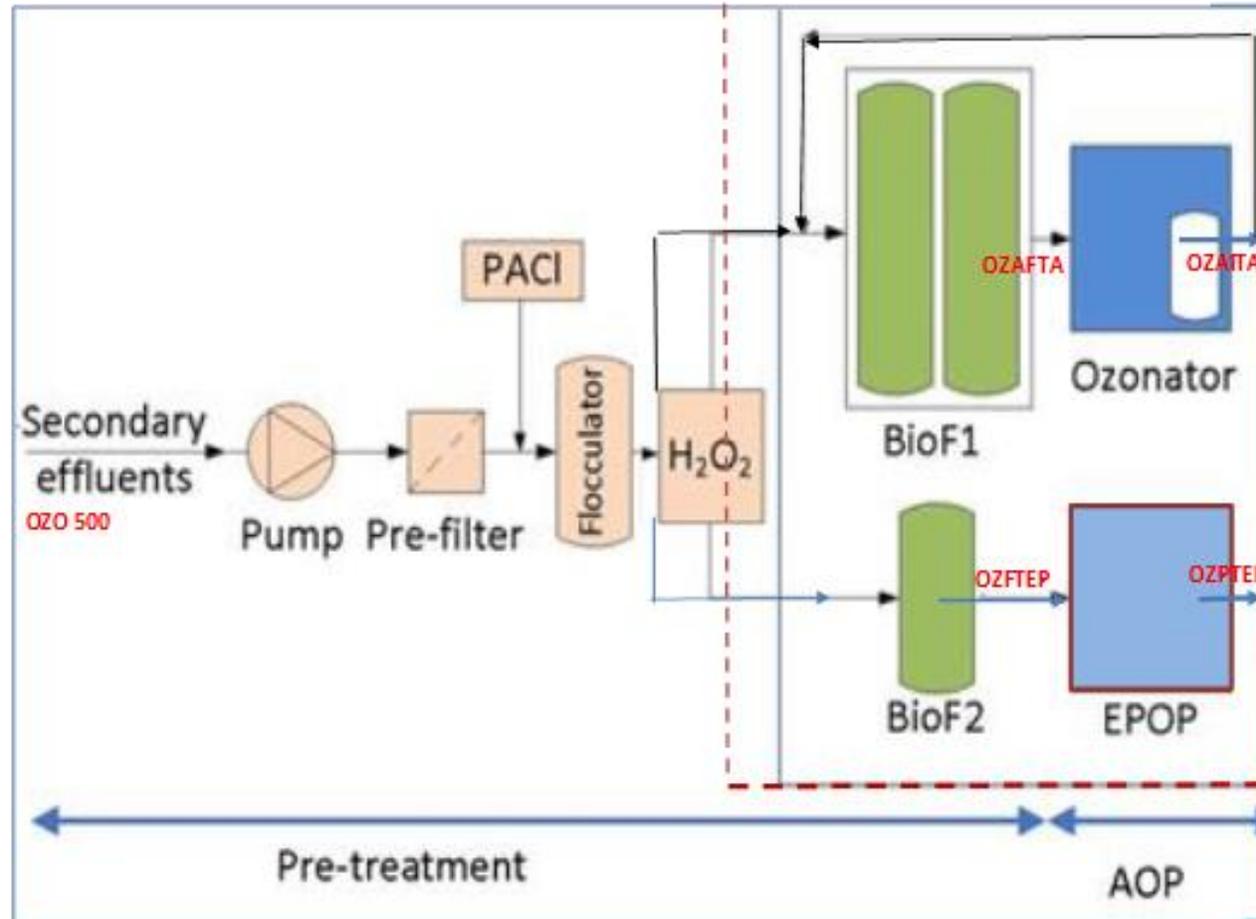
- Stage 2 –
- Free radical formation by the plasma with the carrier gas and Advanced Oxidation

WADIS DEMO SYSTEM AT THE SHAFDAN WWTP



1. Oxygen Generator
2. Pulse Power Generator
3. Multi Electrode EPOP Reactor
4. Nano Bubble Generator (Optional)
5. Contact Tank (optional)

WADIS EPOP AND OZONATION SYSTEMS BLOCK DIAGRAM TESTED AT THE SHAFDAN WWTP



EPOP COMPARE TO OZONATION TEST RESULTS – SHAFDAN WWTP

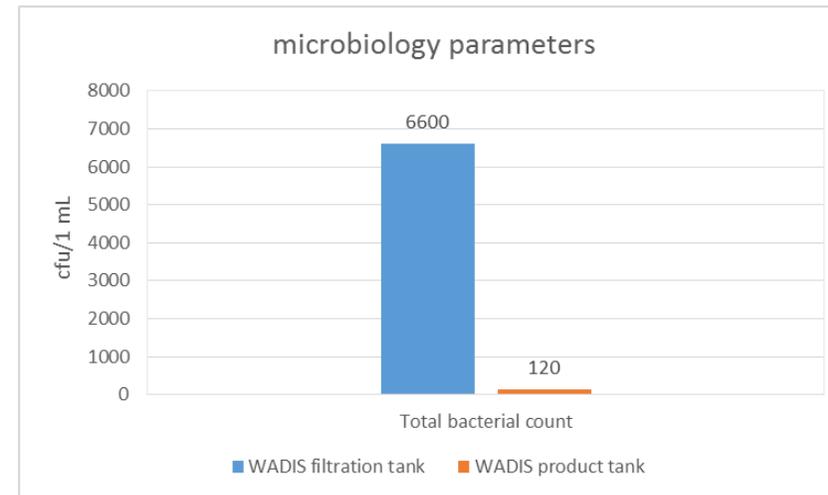
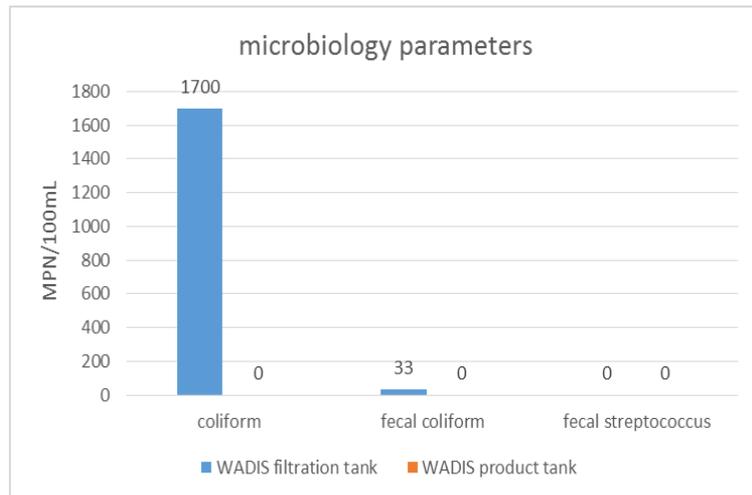
TrOCs (@TZW unless otherwise specified)									Sampling point	Date
SMX	DCF	CBZ	BZF	Naproxen	buprofer	IPRM	IHX	IPDL		
220	840	510	230	700	570	9300	24000	22	WADIS filtration tank	12-Feb-19
0	0	0	0	0	17	1700	6600	0	WADIS product tank	
100%	100%	100%	100%	100%	97%	82%	73%	100%	removal	
170	1000	560	130	670	460	8100	37000	38	Filtration product tank	19-Feb-19
0	0	0	26	0	110	5200	16000	26	OZ Infiltration tank	
100%	100%	100%	80%	100%	76%	36%	57%	32%	removal	
190	1000	620	230	490	270	6900	21000	51	Filtration product tank	5-Mar-19
0	0	0	33	0	59	5700	6600	34	OZ Infiltration tank	
100%	100%	100%	86%	100%	78%	17%	69%	33%	removal	
200	1000	690	250	740	140	6800	20000	32	WADIS filtration tank	12-Mar-19
0	0	0	0	0	0	130	580	0	WADIS product tank	
100%	100%	100%	100%	100%	100%	98%	97%	100%	removal	
210	790	610	200	480	170	8900	26000	59	Filtration product tank	19-Mar-19
0	0	0	29	0	13	5400	21000	37	OZ Infiltration tank	
100%	100%	100%	86%	100%	92%	39%	19%	37%	removal	
230	1100	710	250	670	190	10000	32000	74	WADIS filtration tank	19-Mar-19
0	0	0	11	0	0	4700	17000	36	WADIS product tank	
100%	100%	100%	96%	100%	100%	53%	47%	51%	removal	



EPOP at the best parameters was able to decompose 97% minimum of all tested micro-pollutants, much better than Ozonation, especially on “difficult” molecules.

EPOP COMPARE TO OZONATION MICROBIOLOGICAL RESULTS – SHAFDAN WWTP

Sampling Point	CRYPTOSPORIDIUM	GIARDIA	Fecal Streptococcus	Fecal Coliform	Coliform	Total Bacterial Count
Control	0.40	0.80	<1.8	33	1700	6600
OZONATION	0	0	0	5	79	70000
% removal	100%	100%	ND	85%	95%	0%
WADIS	0.6	0	0	0	0	120
% removal	0	100%	ND	100%	100%	98%



DBPS FORMATION: EPOP COMPARED TO OZONATION

DATE	DBPs	
Joint Sampling Dates	BrO3-	NDMA
	µg/L	ng/L
Average Addition Ozonation	12.0	46
Average Addition WADIS	3.1	34
Efficiency	74%	27%

BrO3- µg/L	NDMA ng/L	Sampling point	AOP	DATE
	2	Filtration product tank	OZONATION	19.2.19
10	62	Infiltration tank		
10	60	Addition		
		WADIS filtration tank	WADIS	
3.7	33	WADIS product tank		
3.7	33	Addition		
	NM	Filtration product tank	OZONATION	26.2.19
12		Infiltration tank		
12		Addition		
	NM	WADIS filtration tank	WADIS	
3.2		WADIS product tank		
3.2		Addition		
	13	Filtration product tank	OZONATION	5.3.19
13	53	Infiltration tank		
13	40	Addition		
	3	WADIS filtration tank	WADIS	
3.6	29	WADIS product tank		
3.6	26	Addition		
	15	Filtration product tank	OZONATION	19.3.19
13	53	Infiltration tank		
13	38	Addition		
	4	WADIS filtration tank	WADIS	
1.8	46	WADIS product tank		
1.8	42	Addition		

EPOP POWER CONSUMPTION COMPARED TO OTHER AOP PROCESSES

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D.B. Miklos et al / Water Research 139 (2018) 118–131

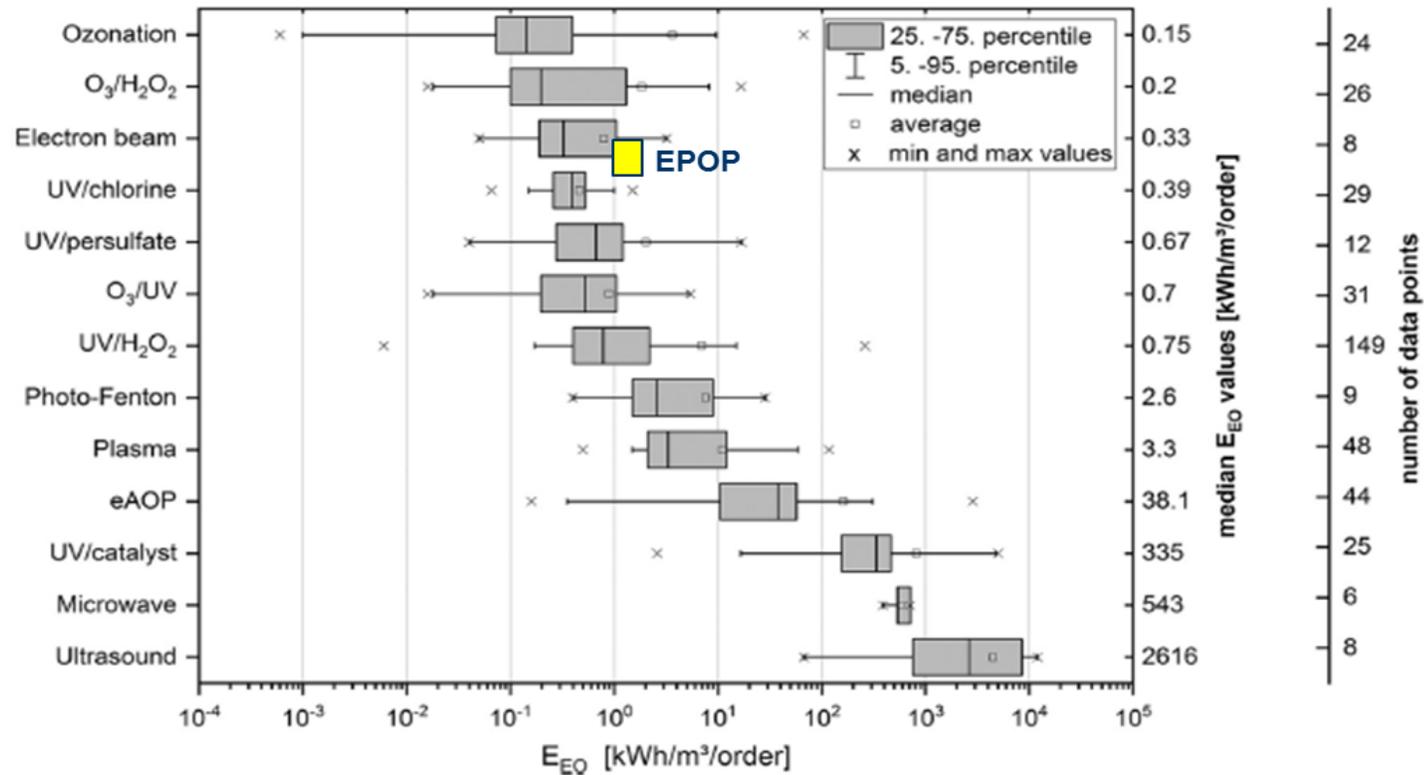


Fig. 2. Overview of published E_{EO} -values of different AOPs sorted according to median values. For O₃- and UV-based AOP data, only substances resistant to direct ozonation/photolysis are shown (references are shown in Table S1). Median values and number of data points are reported on the second and third y-axis, respectively.

CONCLUSIONS

- EPOP and Ozonation results showed **similar** reductions for the **easily degradable** TrOCs.
- EPOP achieved **better results** for the ozone-resistance **compounds**, as Iodine compounds
- EPOP results show the decomposition of more than **97% of all tested TrOCs** at the best parameters.
- EPOP DBPs are at much lower levels than the ozone-based AOP, (bromate and NDMA formation).
- Microbial parameters evaluated the disinfection abilities of the EPOP system, which reached full microbial disinfection.
- EPOP energy consumption was greater than in the Ozonation process.

THANKS



- EU Horizon 2020 AquaNES project



- Mekorot – Israel National Water Company



Reference: Electro-Pulse Oxidation Process (EPOP) – An alternative AOP as pre-treatment for Soil-Aquifer Treatment of secondary effluents for Indirect Potable Reuse, Oren Gafri, et al, IOA World Congress & Exhibition, Nice, France, 20-25 October, 2019

Recent advances in the production of oxidants by electrochemical processes for water disinfection

ENGRACIA LACASA (UNIVERSITY OF CASTILLA-LA MANCHA, SPAIN)



RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

nature
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NEWS | 31 January 2022

The staggering death toll of drug-resistant bacteria

Global survey shows that in 2019, antimicrobial resistance killed more people than HIV/AIDS or malaria.

Antimicrobial resistance now a leading cause of death worldwide, study finds

Lancet analysis highlights need for urgent action to address antibiotic-resistant bacterial infections

U.S. deaths from antibiotic resistant 'superbugs' rose 15% in 2020

By Marcus Willeke

World Health Organization
Antimicrobial resistance

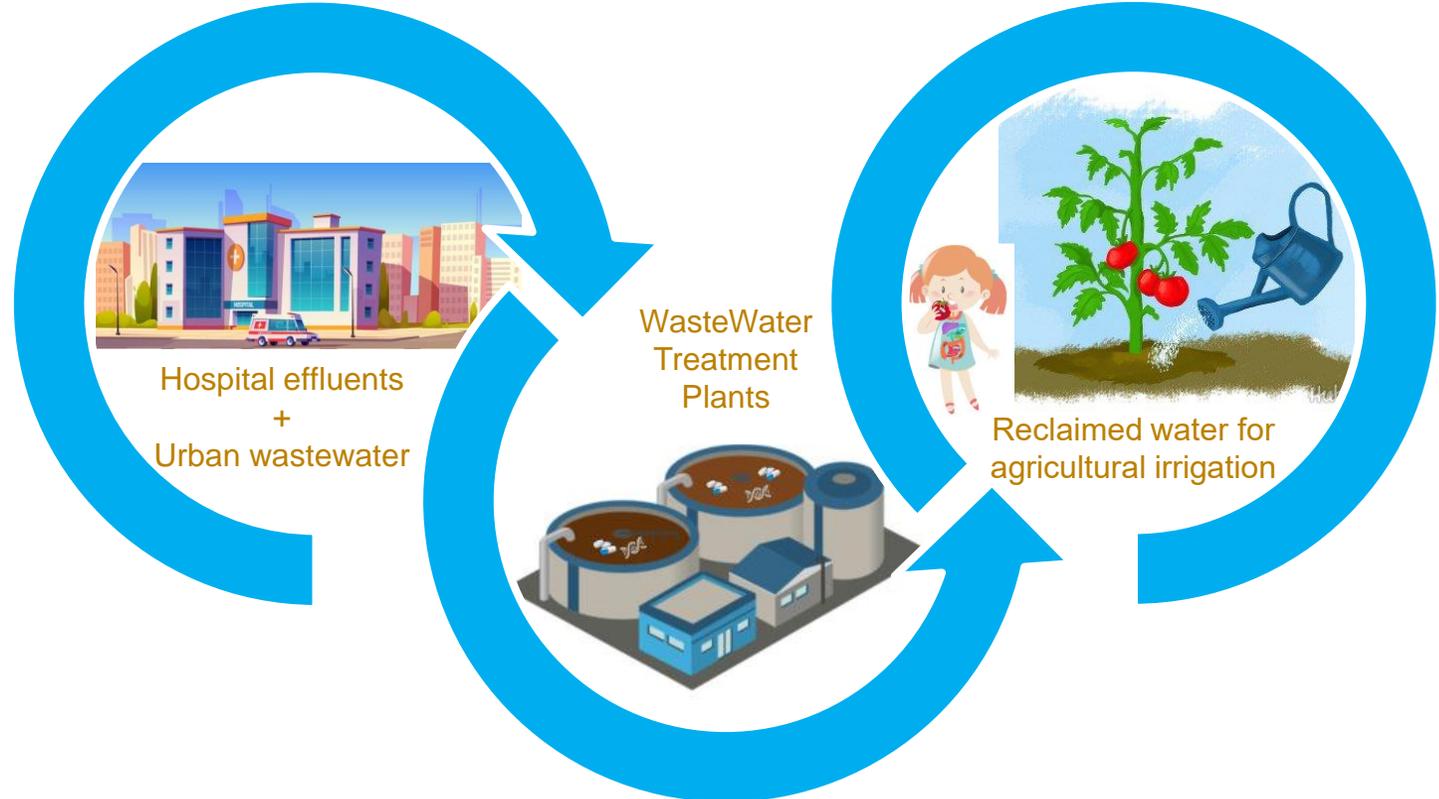
17 November 2021

Key facts

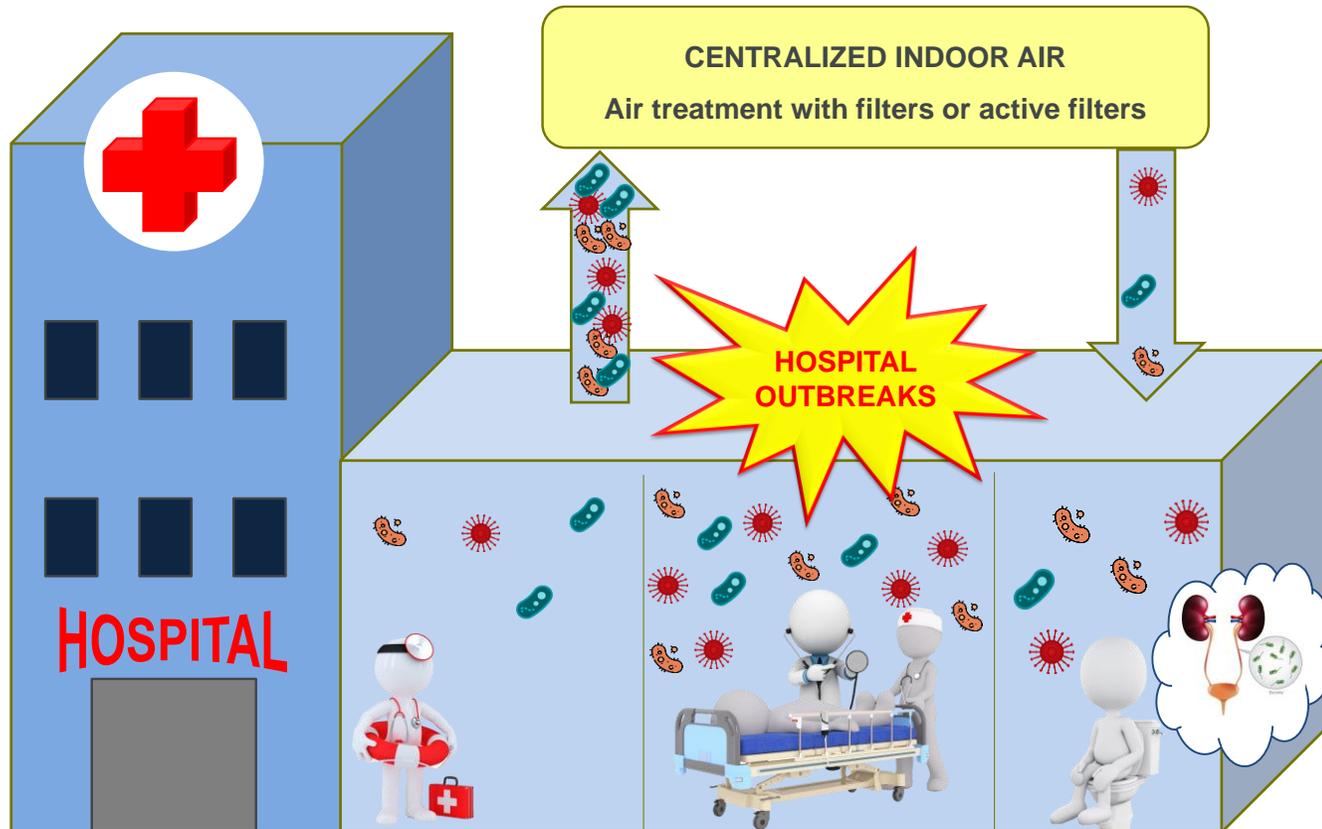
- Antimicrobial resistance (AMR) is a global health and development threat. It requires urgent multisectoral action to achieve the Sustainable Development Goals (SDGs).
- WHO has declared that AMR is one of the top 10 global public health threats facing humanity.
- Misuse and overuse of antimicrobials are the main drivers in the development of drug-resistant pathogens.
- Lack of clean water and sanitation and inadequate infection prevention and control promotes the spread of microbes, some of which can be resistant to antimicrobial treatment.
- The cost of AMR to the economy is significant. In addition to death and disability, prolonged illness results in longer hospital stays, the need for more expensive medicines and financial challenges for those impacted.
- Without effective antimicrobials, the success of modern medicine in treating infections, including during major surgery and cancer chemotherapy, would be at increased risk.

What are antimicrobials?

Antimicrobials – including antibiotics, antivirals, antifungals and antiparasitics – are medicines used to prevent and treat infections in humans, animals and plants.



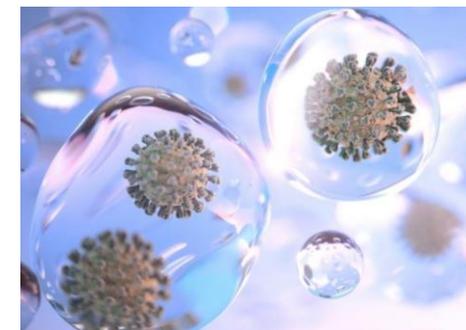
RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION



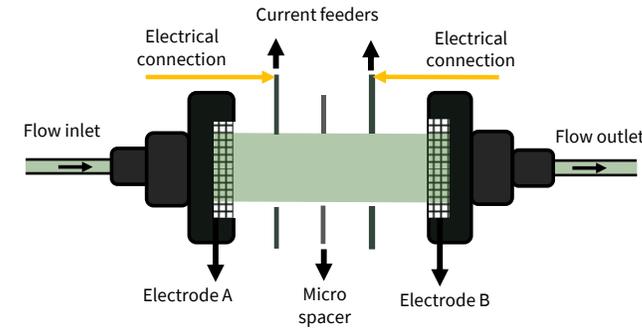
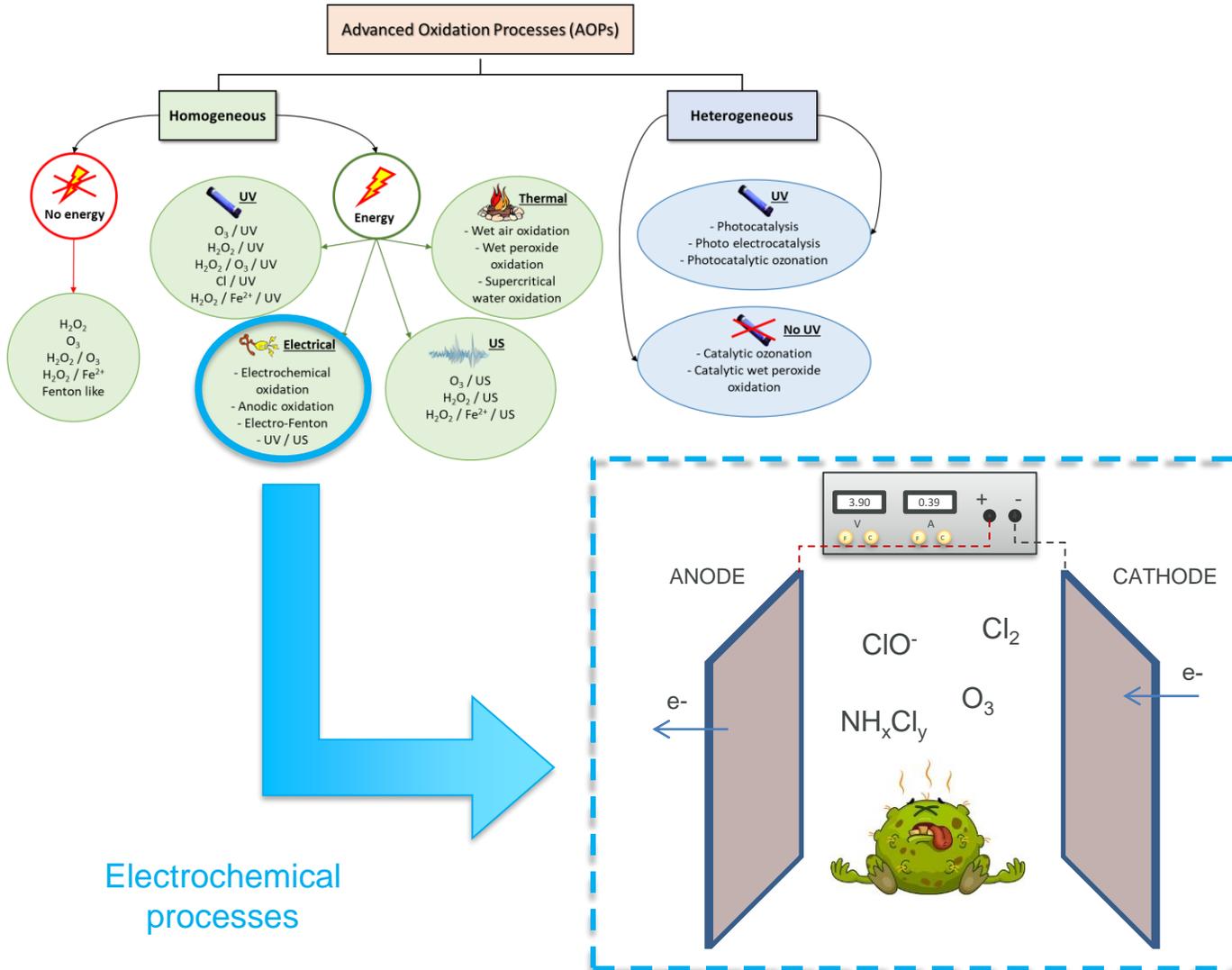
- Liquid hospital effluents



- Gaseous hospital effluents

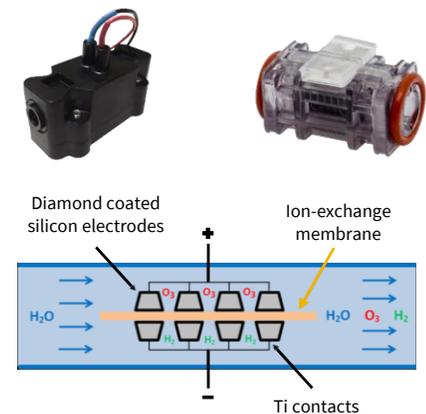


RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION



Microfluidic flow-through electrochemical cell

Electrochemical cells



MIKROZON® cell

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

Oxidants in liquid phase

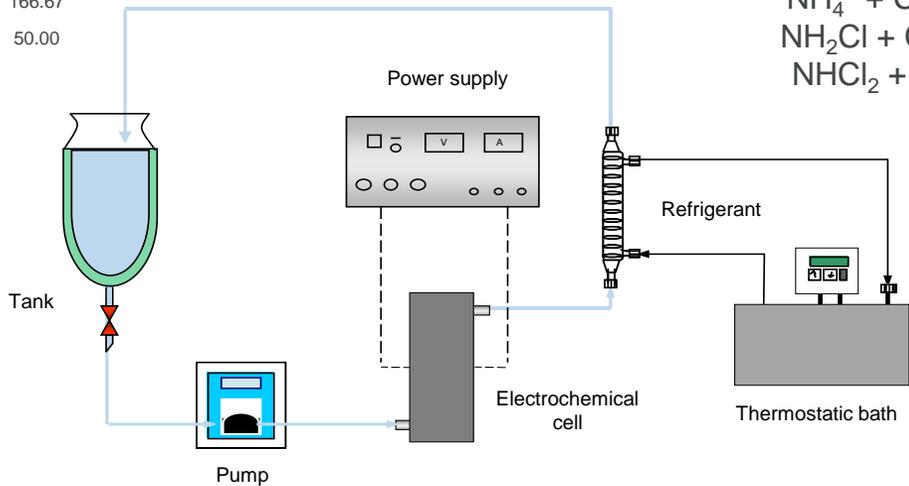


Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes

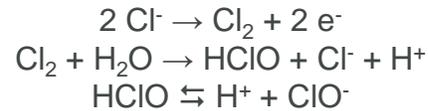


Oxidants in gas phase
Disinfection of gaseous hospital effluents

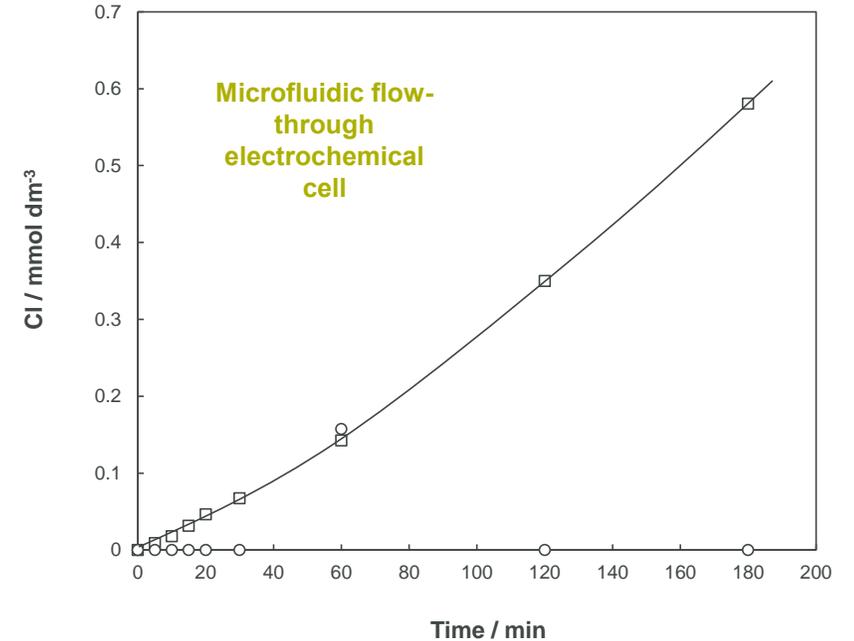
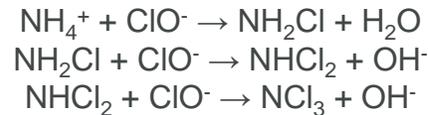
Species	Synthetic hospital urine (mg dm ⁻³)
Cl ⁻	475.52
NO ₃ ⁻	-
PO ₄ ³⁻	59.94
SO ₄ ²⁻	135.58
CO ₃ ²⁻	94.35
Na ⁺	72.34
K ⁺	524.45
NH ₄ ⁺	22.72
Ca ²⁺	10.99
Mg ²⁺	34.33
CH ₄ N ₂ O (Urea)	3,333.33
C ₄ H ₇ N ₃ O (Creatinine)	166.67
C ₅ H ₄ N ₄ O ₃ (Uric acid)	50.00



Hypochlorite



Chloramines



Evolution of chlorine disinfectants as function of the operation time during the electrochemical disinfection of hospital urines. (○) hypochlorite 50 A m⁻²; (□) chloramines 50 A m⁻². Flow-through reactor.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

Oxidants in liquid phase



Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes



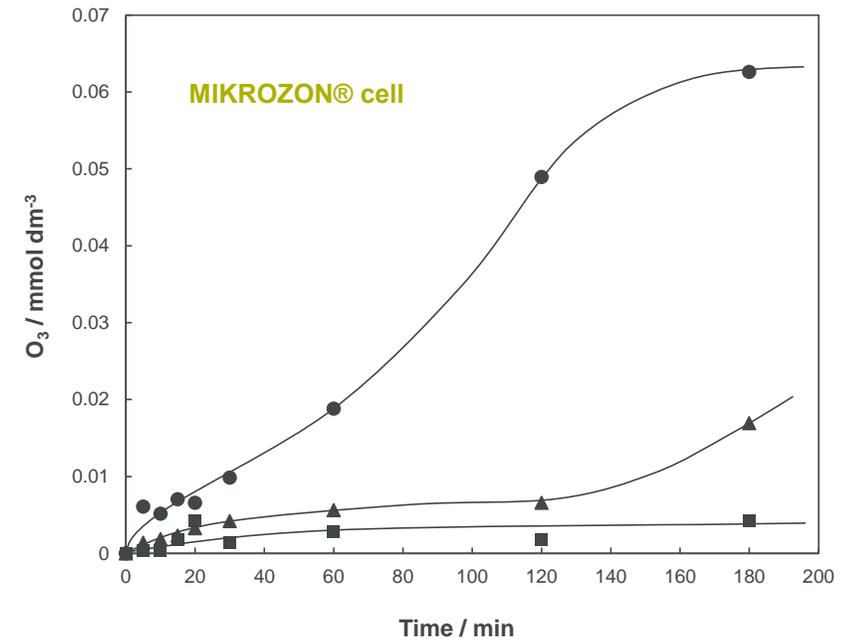
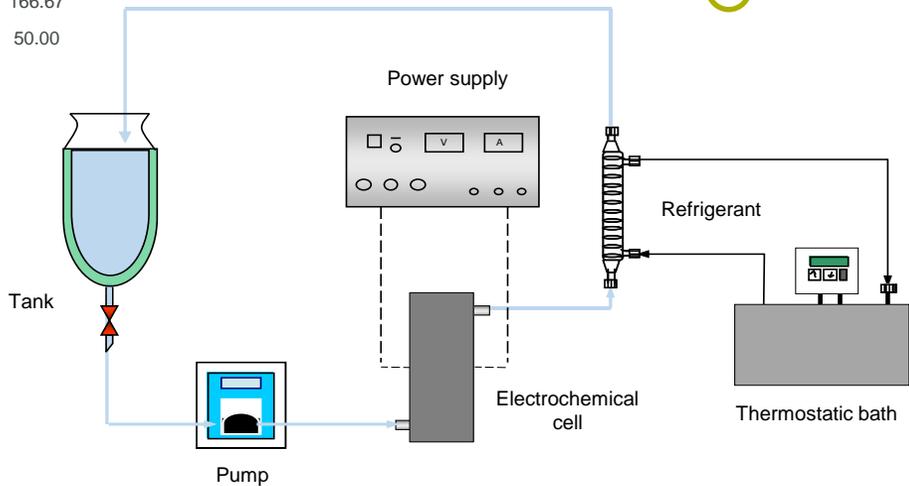
Oxidants in gas phase
Disinfection of gaseous hospital effluents

Species	Synthetic hospital urine (mg dm ⁻³)
Cl ⁻	475.52
NO ₃ ⁻	-
PO ₄ ³⁻	59.94
SO ₄ ²⁻	135.58
CO ₃ ²⁻	94.35
Na ⁺	72.34
K ⁺	524.45
NH ₄ ⁺	22.72
Ca ²⁺	10.99
Mg ²⁺	34.33
CH ₄ N ₂ O (Urea)	3,333.33
C ₄ H ₇ N ₃ O (Creatinine)	166.67
C ₅ H ₄ N ₄ O ₃ (Uric acid)	50.00



Oxidation potential

Ozone (E⁰: 2.07 V)
Hypochlorite (E⁰: 1.49 V)
Chloramines (E⁰: 1.40 V)



Time course of the concentration of ozone electrogenerated during the disinfection of urines using the MIKROZON® reactor. Intensities: (■) 0.1 A; (▲) 0.5 A; (●) 1.0 A.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

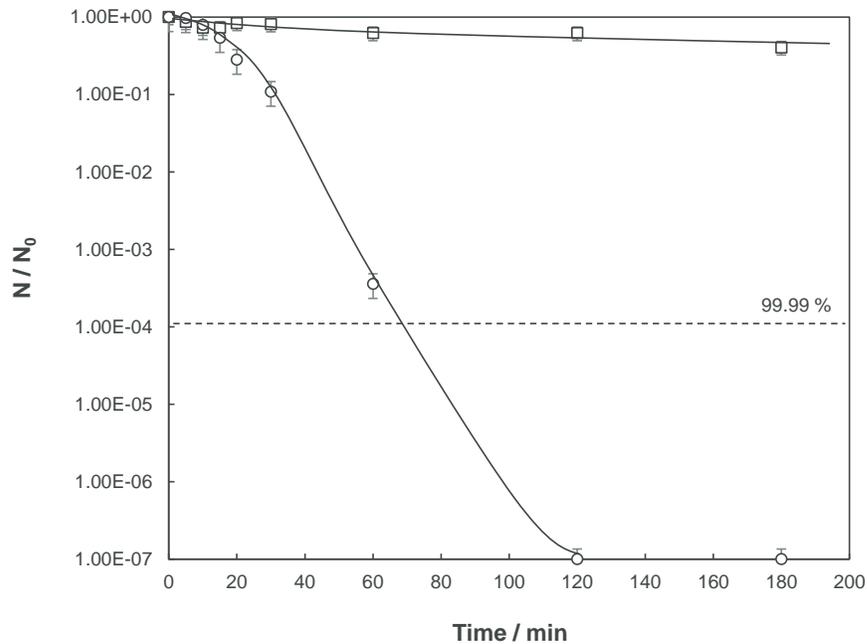
Oxidants in liquid phase
Disinfection of aqueous hospital effluents



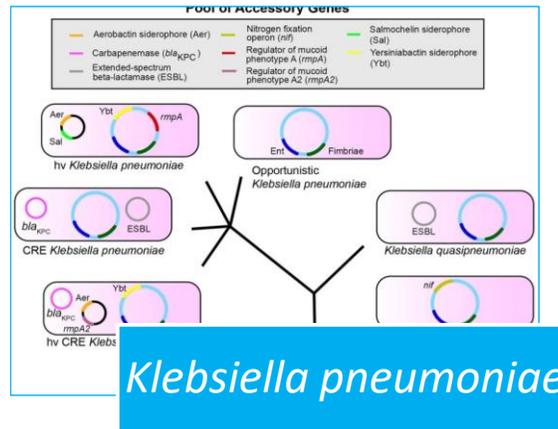
Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes



Oxidants in gas phase
Disinfection of gaseous hospital effluents



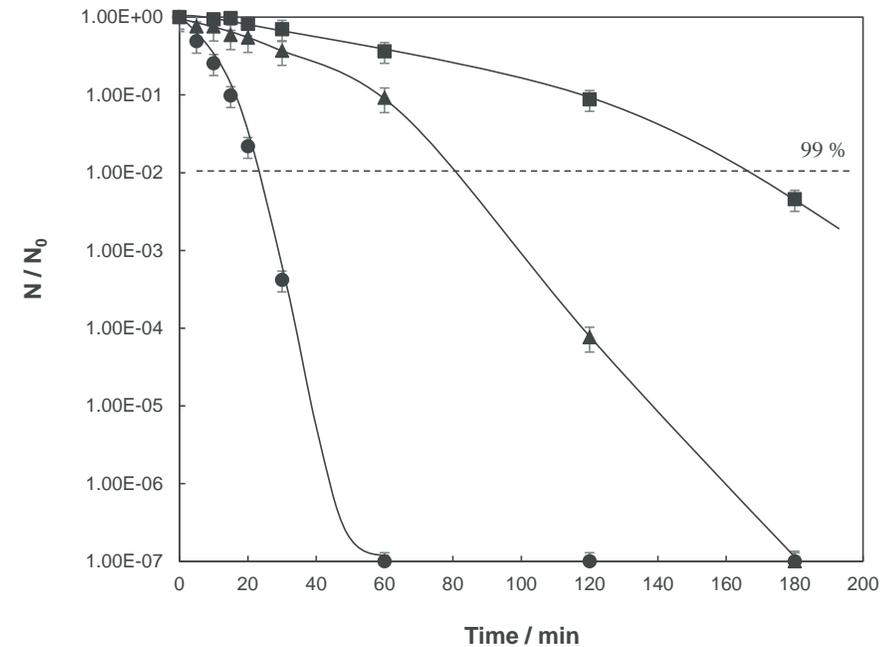
Influence of the current density on the disinfection of urines using the **microfluidic flow-through cell**. Current density: (□) 5 A m⁻²; (○) 50 A m⁻². N₀: 10⁷ CFU mL⁻¹.



Klebsiella pneumoniae

- ✓ The **microfluidic flow-through cell** at 50 A m⁻² attained a complete disinfection (7 log) before 2h.
- ✓ The **MIKROZON® cell** allowed to disinfect urines from current intensities higher than 0.5 A.

[10.1016/j.cej.2020.128253](https://doi.org/10.1016/j.cej.2020.128253)
[10.1016/j.electacta.2021.138343](https://doi.org/10.1016/j.electacta.2021.138343)



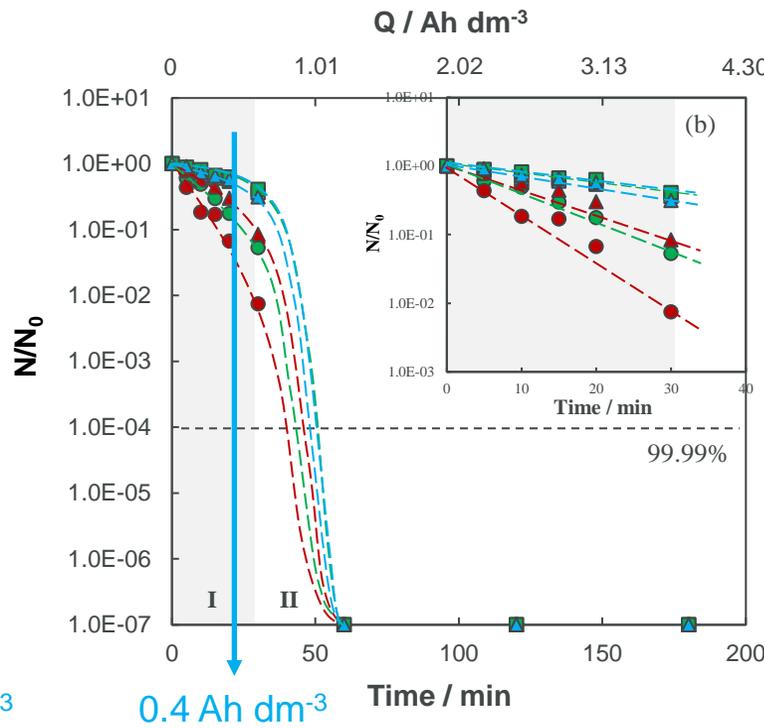
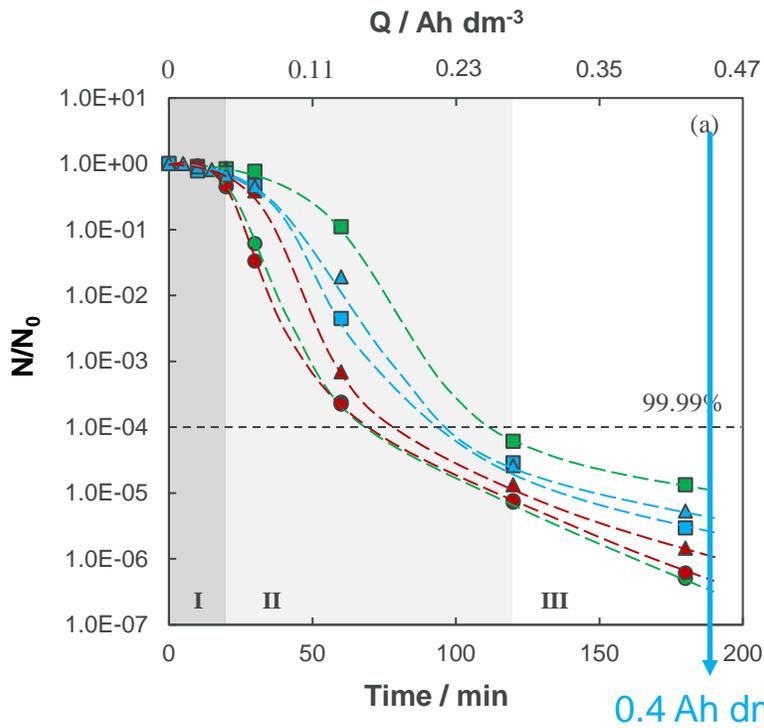
Influence of the current intensity on the disinfection of urines using the **MIKROZON® cell**. (■) 0.1 A; (▲) 0.5 A; (●) 1.0 A; N₀: 10⁷ CFU mL⁻¹.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

Oxidants in liquid phase
Disinfection of aqueous hospital effluents

Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes

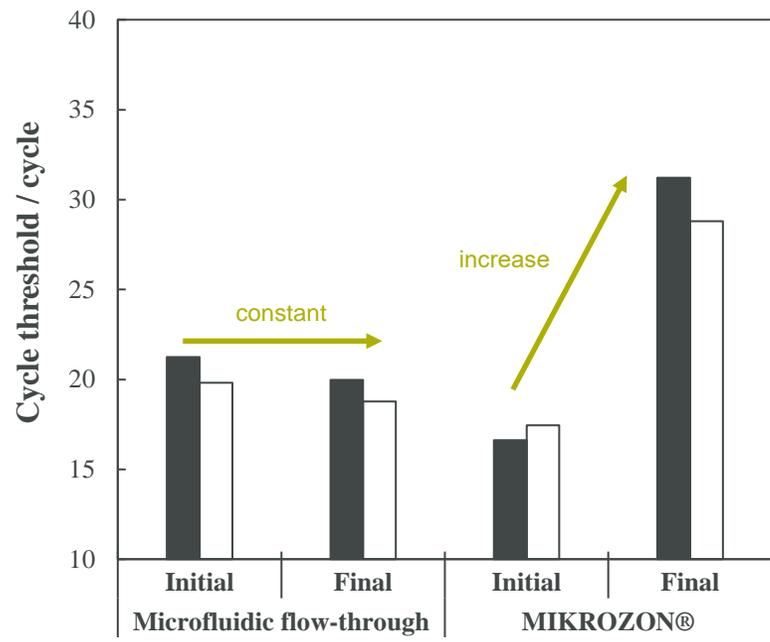
Oxidants in gas phase
Disinfection of gaseous hospital effluents



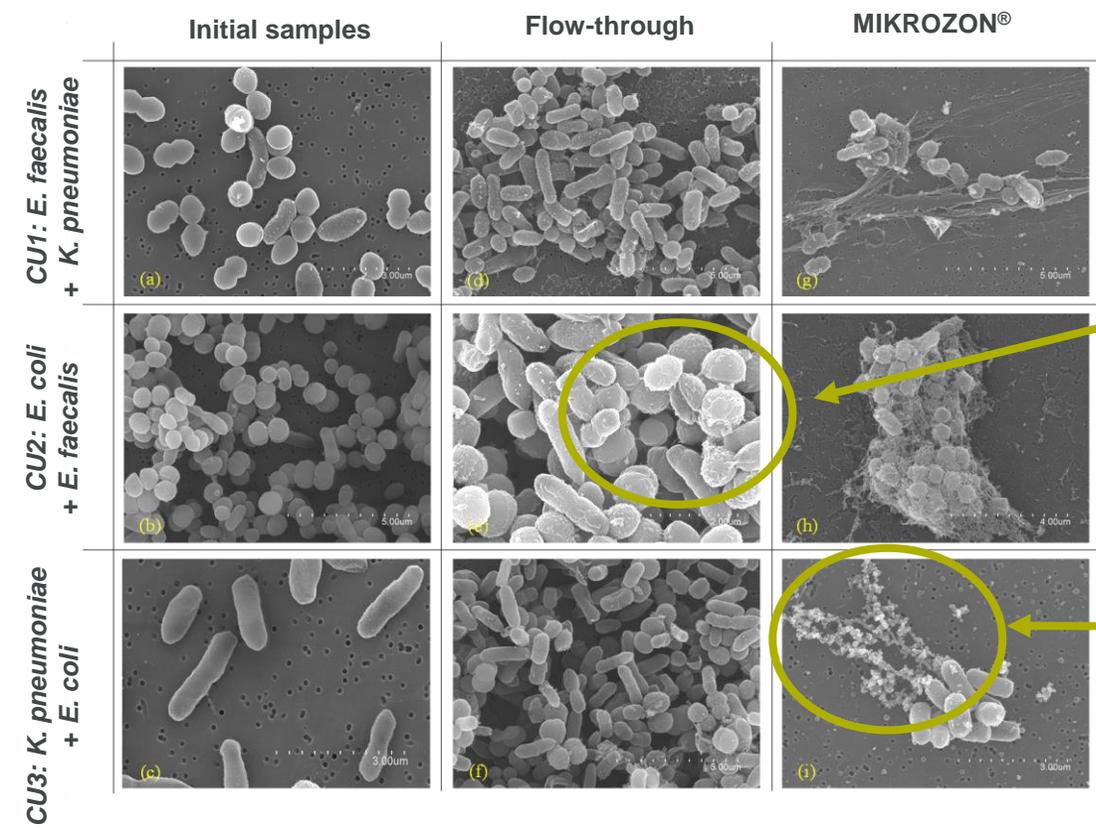
- ✓ The MIKROZON® cell reached the total disinfection (7 logs) after 60 min.
- ✓ The microfluidic flow-through cell achieves up to one order of magnitude higher disinfection efficiencies than the MIKROZON® cell.

Evolution of ARB as function of the experimental time and the applied electric charge during the electrochemical disinfection of complex synthetic hospital urines. (a) microfluidic flow-through cell; (b) MIKROZON® cell. (●) *E. faecalis*; (■) *K. pneumoniae*; (▲) *E. coli*; green symbols: CU1; red symbols: CU2; blue symbols: CU3. N_0 : 10^7 CFU mL⁻¹.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION



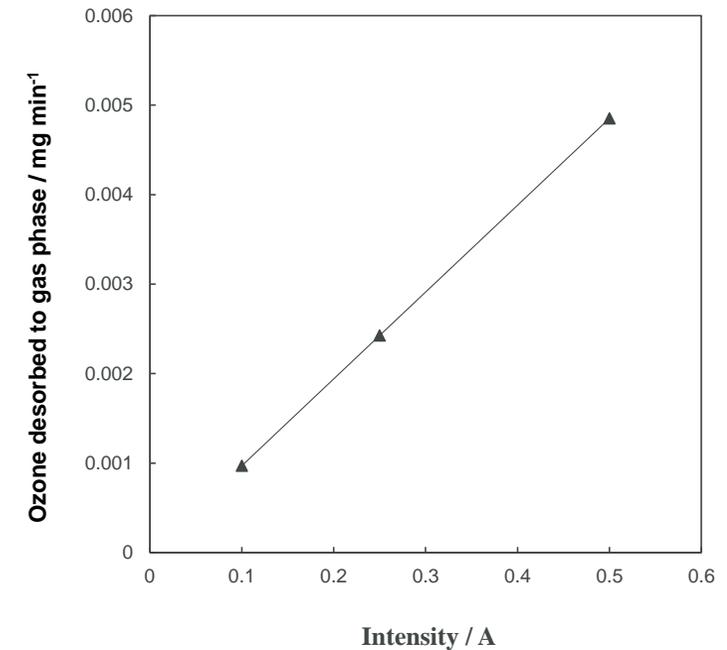
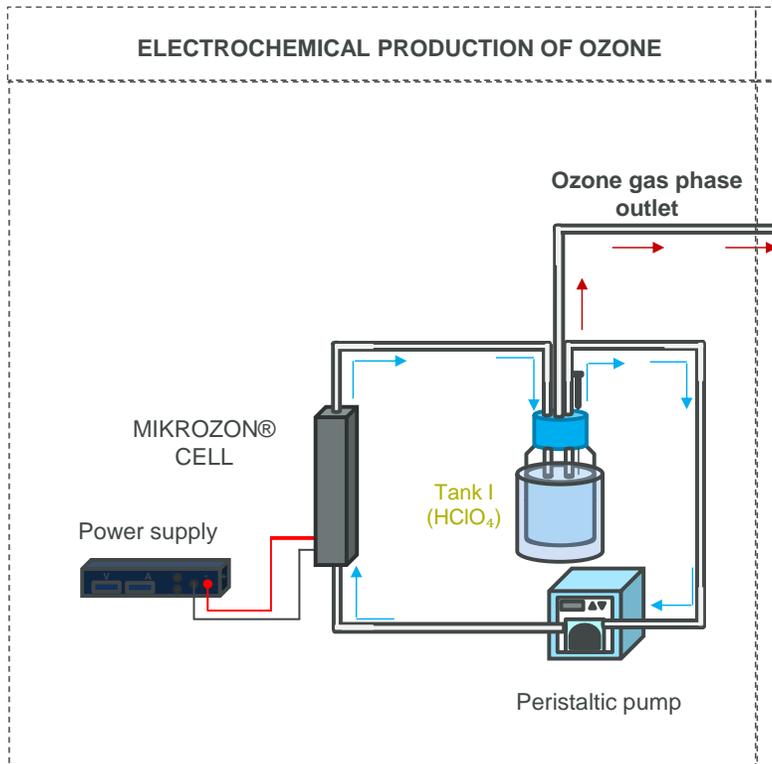
Cycle threshold detection of ARGs during the disinfection of complex synthetic hospital urines, using a microfluidic flow-through reactor or a MIKROZON® cell. ARGs: *bla_{KPC}* gene. (■) CU1: *E. faecalis* + *K. pneumoniae*; (□) CU3: *K. pneumoniae* + *E. coli*.



Final samples images obtained with the microfluidic flow-through reactor showed that chlorine derived disinfectants induced small pits and bulges in the cell walls.

Ozone based disinfection with the MIKROZON® cell induced severe damages in the cell walls, resulting in the integrity loss of bacterial structures.

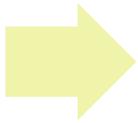
RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION



Evolution of ozone gas that is electrochemically produced in liquid phase (0.5 mM HClO₄) using a MIKROZON® cell.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

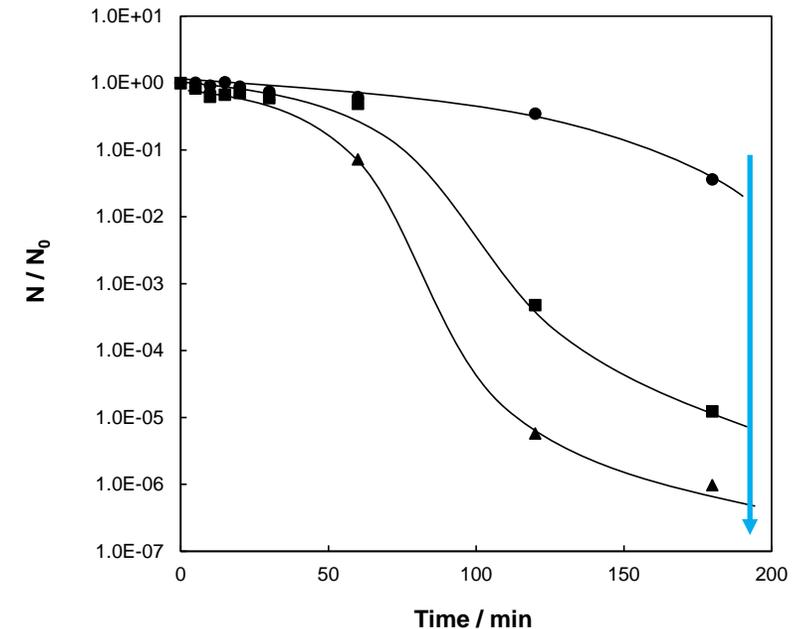
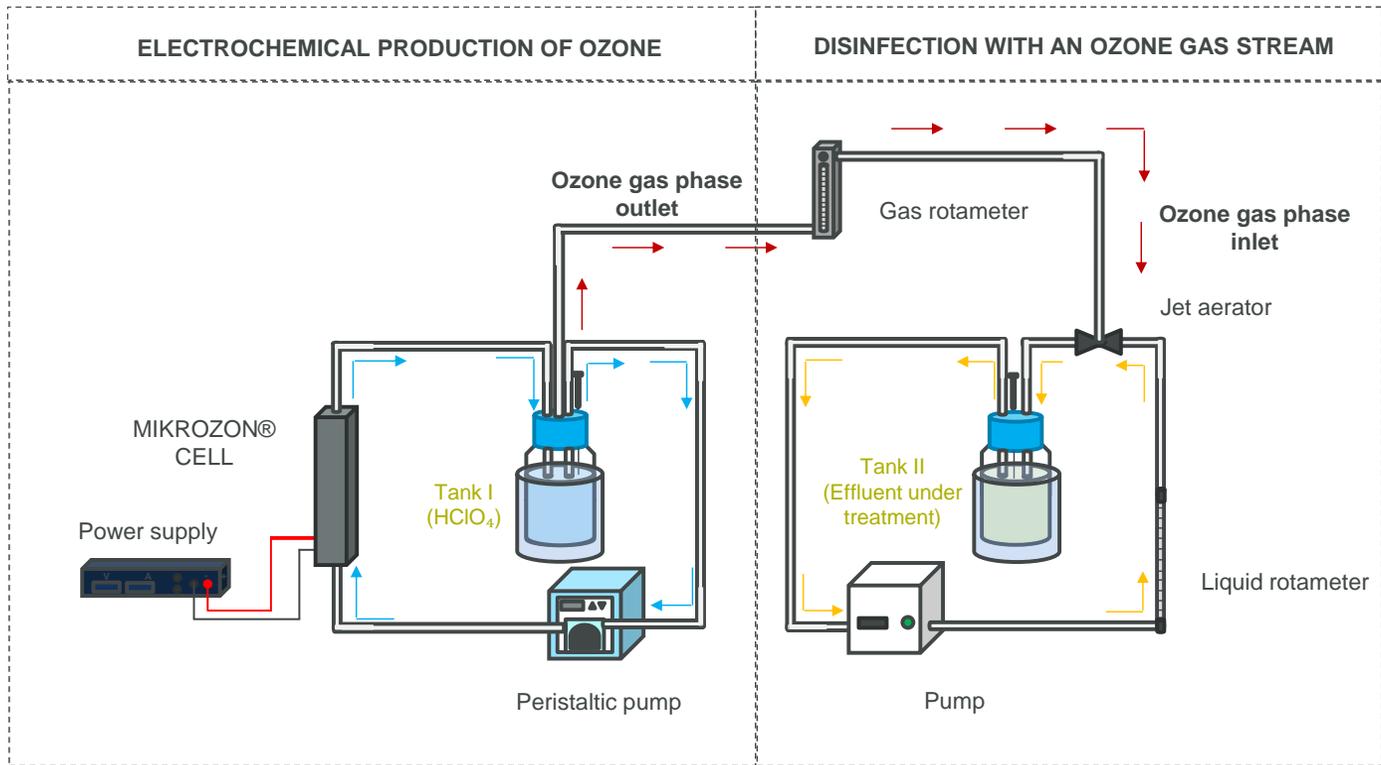
Oxidants in liquid phase
Disinfection of aqueous hospital effluents



Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes

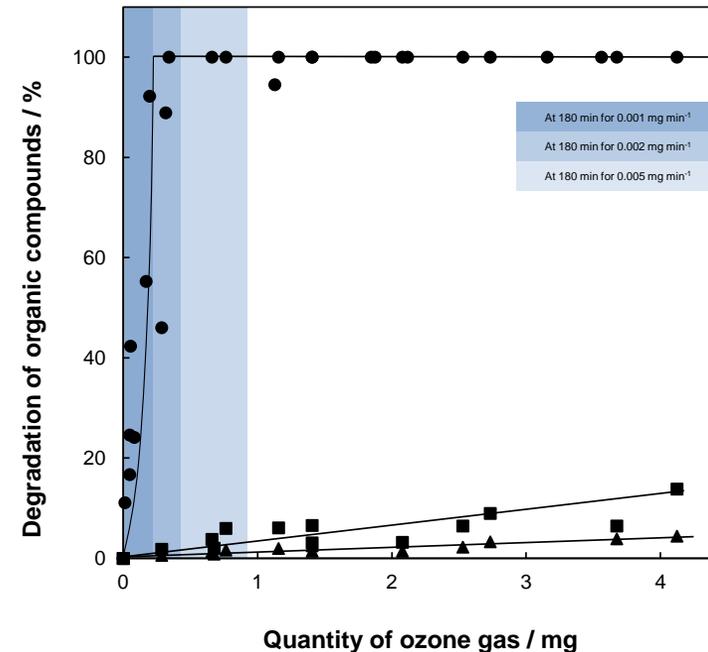
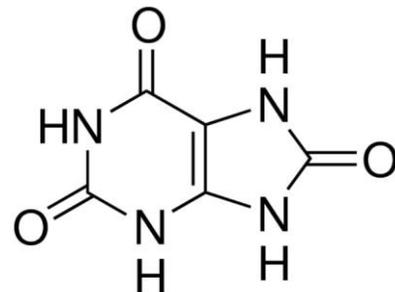
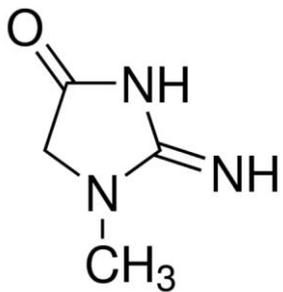
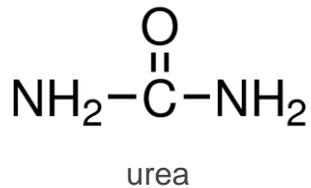


Oxidants in gas phase
Disinfection of gaseous hospital effluents



Evolution of bacteria as a function of time using the ozone gas stream produced using a MIKROZON® cell. Mass flow of ozone gas: (●,○) 0.001 mg min⁻¹, (■,□) 0.002 mg min⁻¹, (▲,△) 0.005 mg min⁻¹. Simulated liquid hospital effluents: urine. Target bacteria: 10⁷ CFU mL⁻¹ of *K. pneumoniae* ATCC BAA 1705.

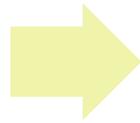
RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION



Evolution of organic compounds as a function of the quantity of ozone gas introduced in the absorption-based process. Organic compounds: (▲) urea, (■) creatinine, (●) uric acid. Simulated liquid hospital effluent: patients' urine.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

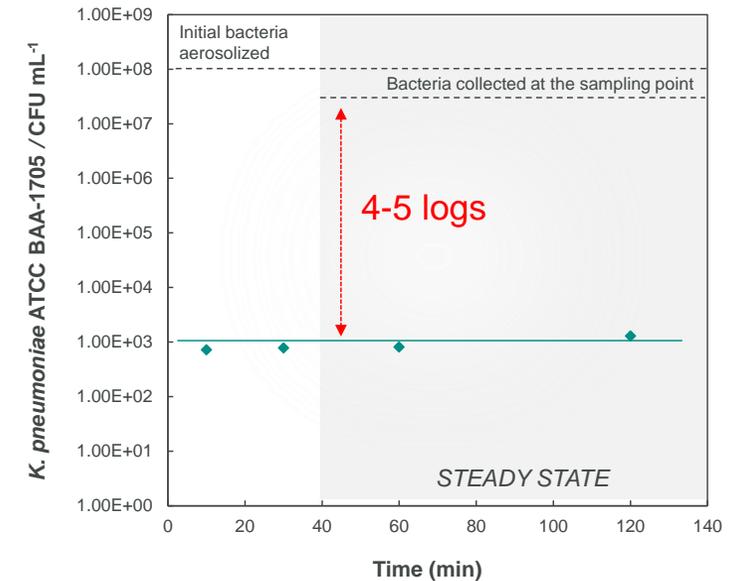
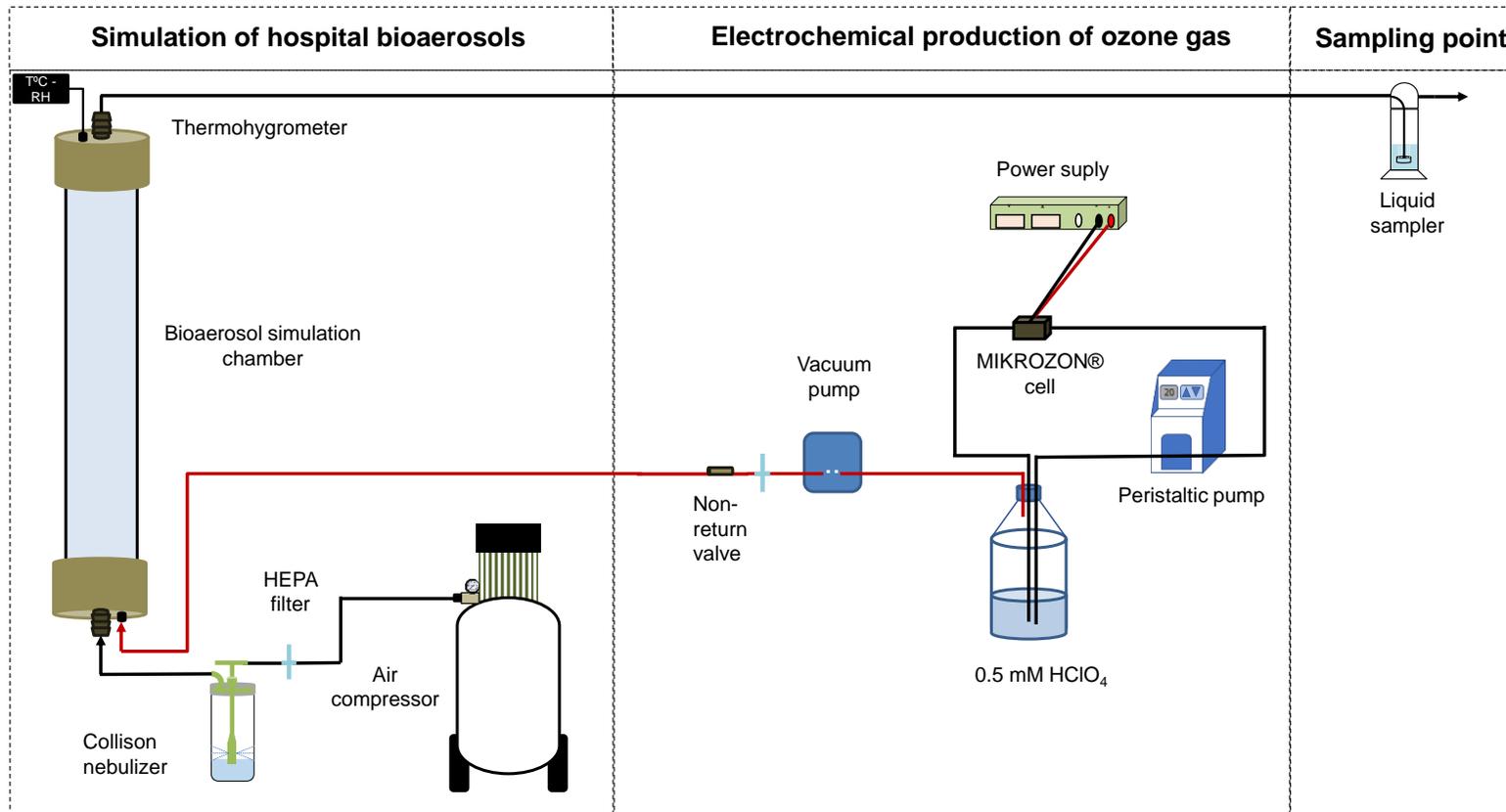
Oxidants in liquid phase
Disinfection of aqueous hospital effluents



Oxidants in gas phase
Disinfection of aqueous hospital effluents based on absorption processes



Oxidants in gas phase
Disinfection of gaseous hospital effluents



Inactivation of *Klebsiella pneumoniae*, during the continuous injection of an electrogenerated ozone gas stream at 0.16 mg min⁻¹. Synthetic aqueous aerosolized solution: urine within an initial concentration of 10⁸ CFU mL⁻¹ of bacteria.

RECENT ADVANCES IN THE PRODUCTION OF OXIDANTS BY ELECTROCHEMICAL PROCESSES FOR WATER DISINFECTION

Conclusions

- ✓ The concentration of **chloramines** increases with the current density and their formation is the highest using the flow-through cell. A complete disinfection (7 log unit decay of the *waterborne Klebsiella pneumoniae*) was attained before 120 min using a flow-through reactor with MMO anode. In addition, the use of a **commercial electro-ozonizer** allows to disinfect urines from current intensities higher than 0.5 A.
- ✓ The **microfluidic flow-through cell** achieved removal rates between 5 and 6 logs after 180 min whereas the **MIKROZON® cell** reached the total disinfection (7 logs) after 60 min, during the disinfection of complex hospital urines. However, the **microfluidic flow-through cell** could be said to achieve up to one order of magnitude higher disinfection efficiencies than the **MIKROZON® cell**, attending to the applied electric charge needed to reach a similar disinfection removal.
- ✓ The stripping of **ozone gas from a MIKROZON® cell** leads to attain the complete inactivation of the *waterborne Klebsiella pneumoniae* in hospital wastewater, using an absorption-based process.
- ✓ The electrochemical technology may be coupled into the hospital air-conditioning installations since electrogenerated gaseous oxidants as **ozone** are able to maintain a continuous **inactivation of airborne** with more than 4-5 logs removal.

Questions & Comments?



Acknowledgments:

SBPLY/21/180501/000035

PID2019-110904RB-I00



Engracia Lacasa

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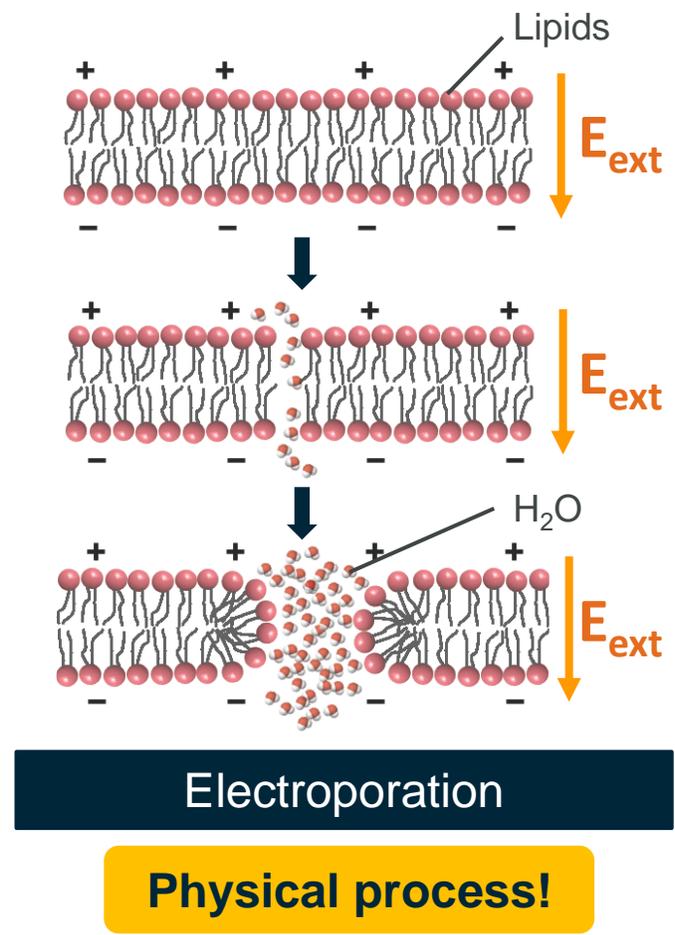
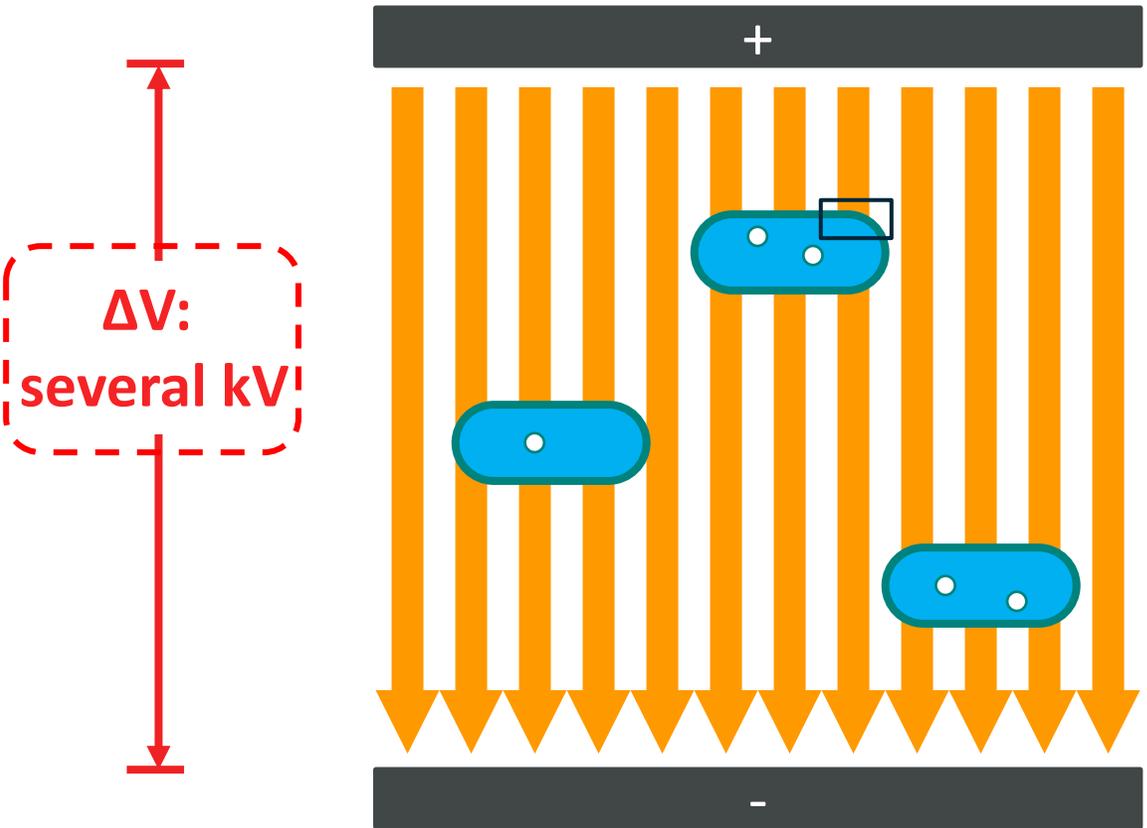


Locally Enhanced Electric Field Treatment (LEEFT)

JIANFENG ZHOU



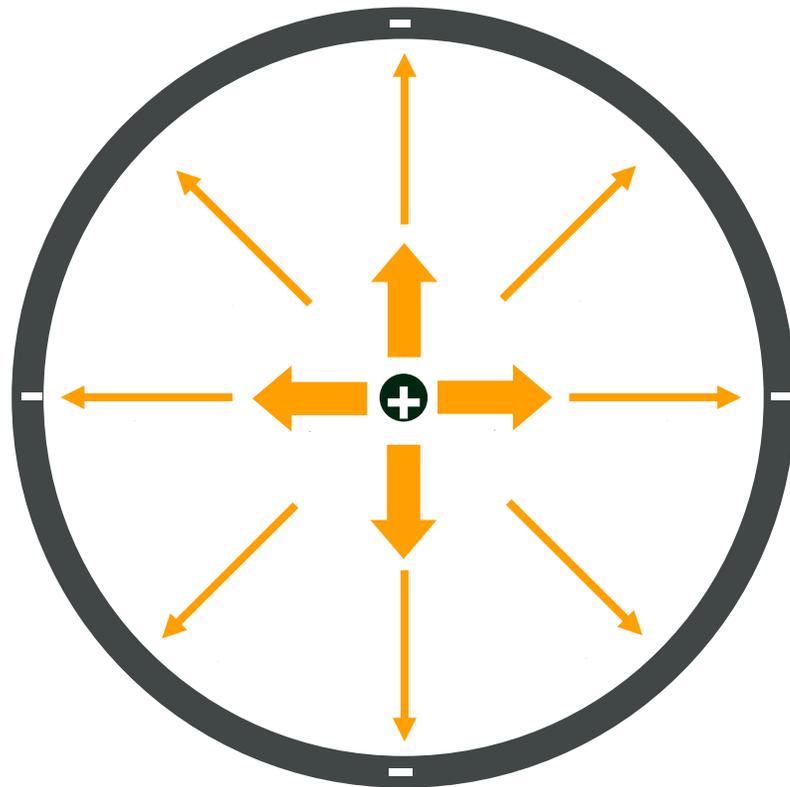
(CONVENTIONAL) ELECTRIC FIELD TREATMENT



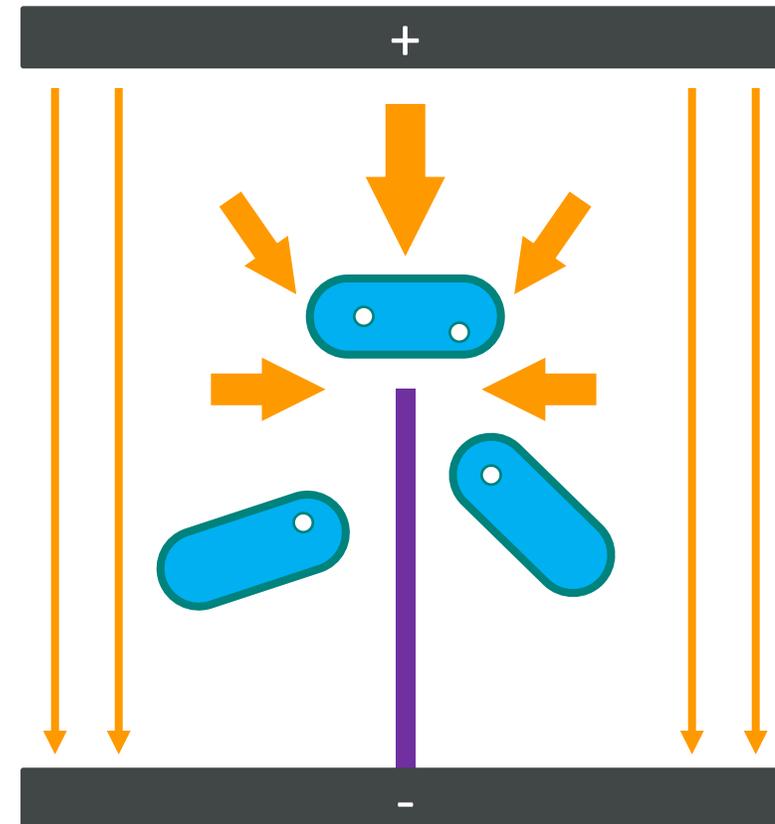
J.Zhou, et al. *Water Res.* 2021, 117817, J.Zhou, et al. *Front. Environ. Sci. Eng.* 2020, 14(5): 78, J.Zhou, et al. *J. Mater. Chem.A.* 2020, 8, 12262-12277

LOCALLY ENHANCED ELECTRIC FIELD TREATMENT (LEEFT)

Macro-scale enhancement



Micro-scale enhancement



ROADMAP OF LEEFT TECHNOLOGY



the international water association

01

System design

- Coaxial-electrode configuration
- Electrode development

02

Process design

- LEEFT + Ozone
- LEEFT / Electrochemical Cu

03

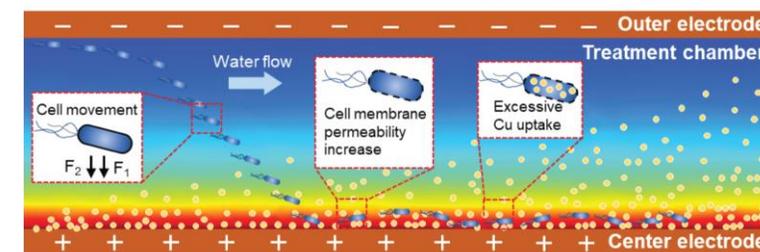
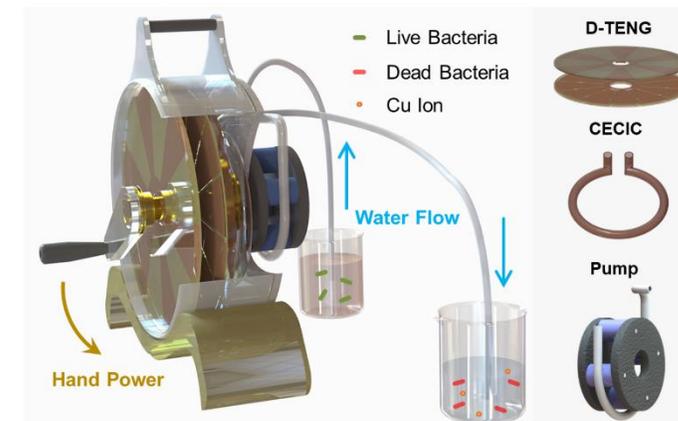
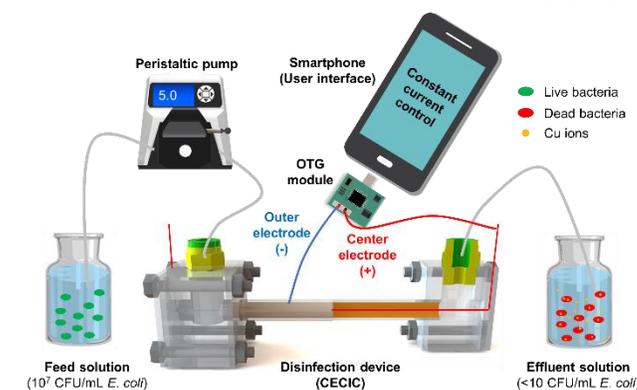
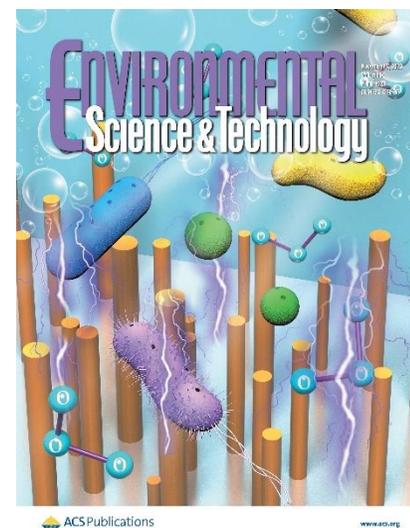
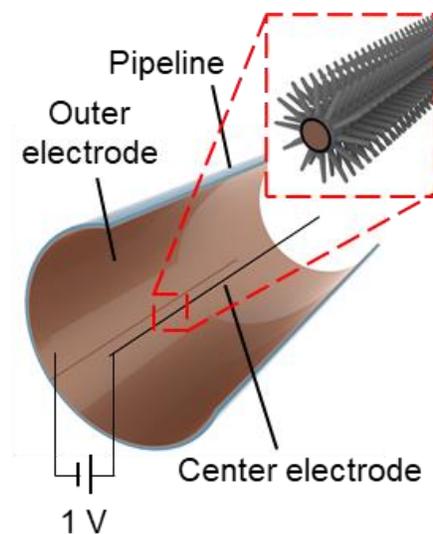
Mechanism revealing

- Lethal threshold
- Computational simulation

04

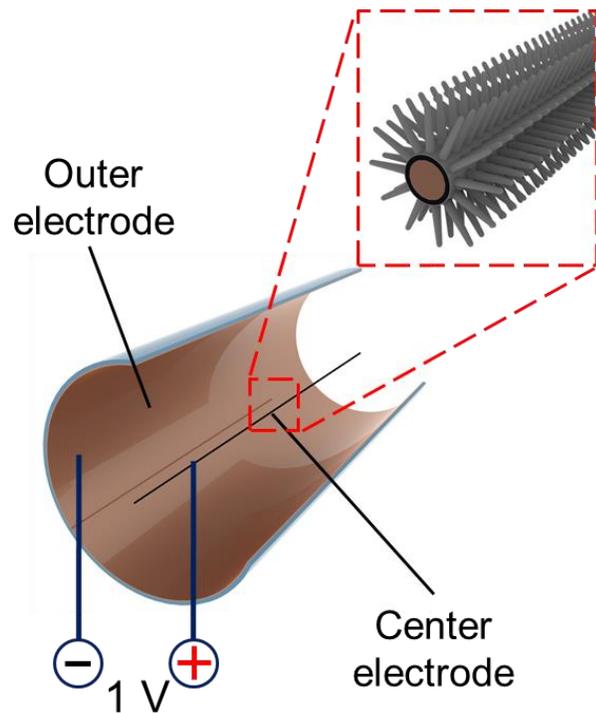
Novel energy sources

- TriboPump
- Smartphone workstation



SYSTEM DESIGN: COAXIAL CONFIGURATION

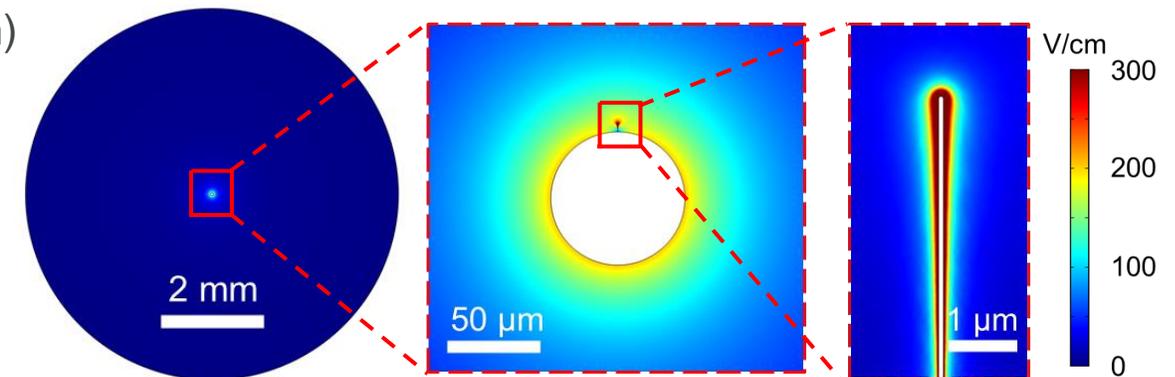
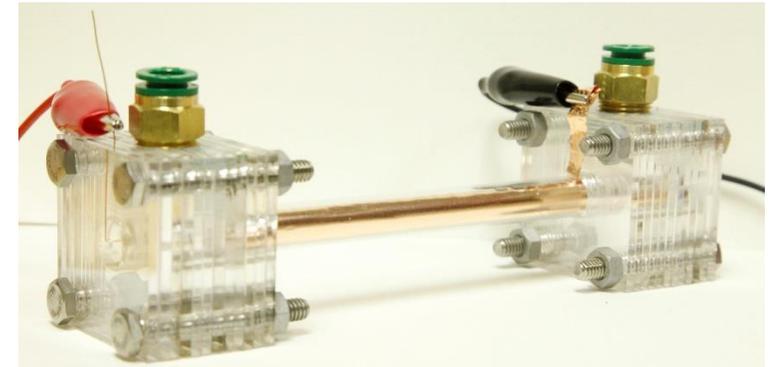
- Combine Macro- & Micro-scale enhancement
- Tubular coaxial-electrode** configuration
 - Two levels of electric field enhancement



Enhancement factor:

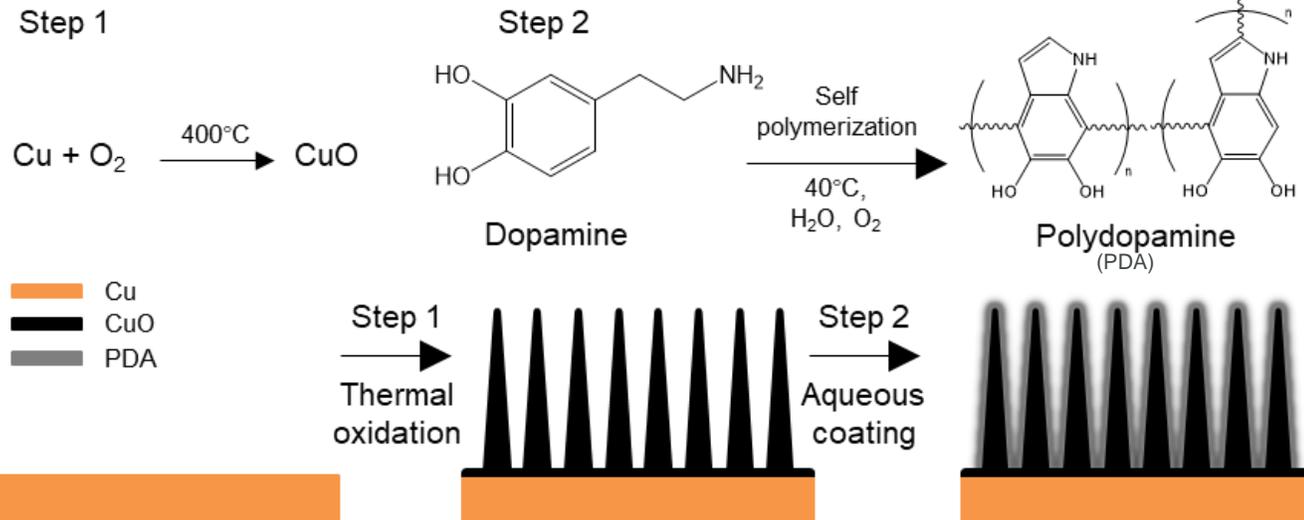
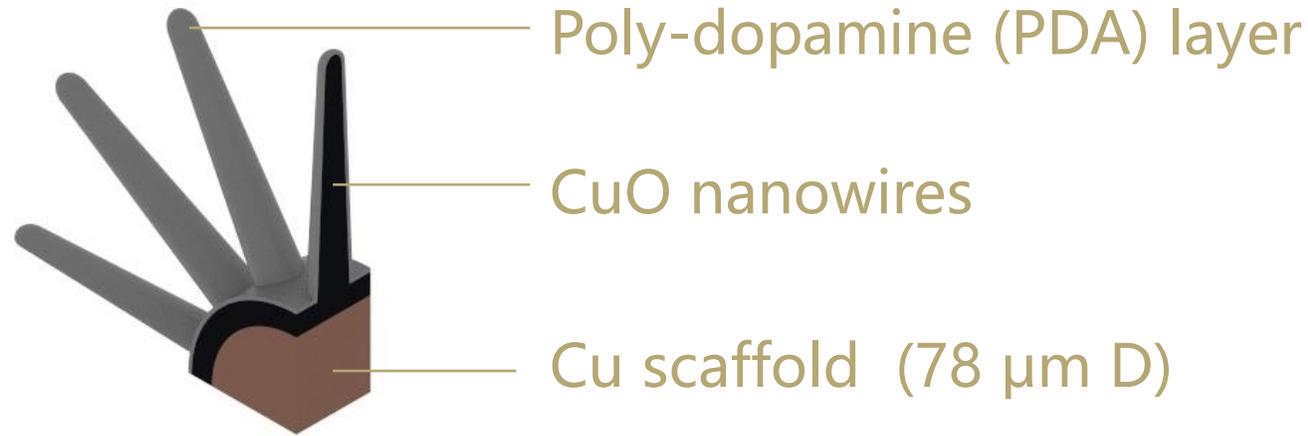
$$f = \frac{R}{r} \cdot \frac{1}{\ln \frac{r}{R}} = 26$$

($R=0.475$ cm, $r=76$ μ m)

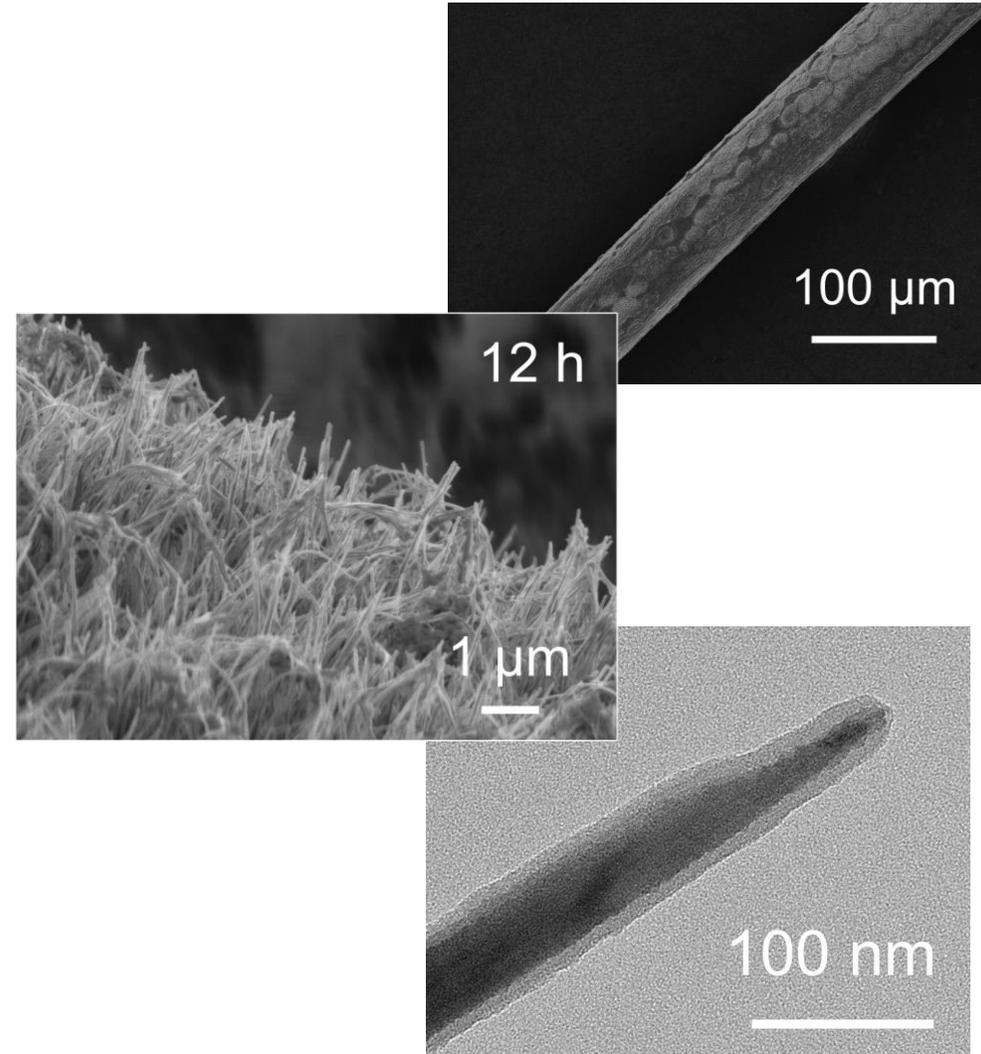


Electric field simulation

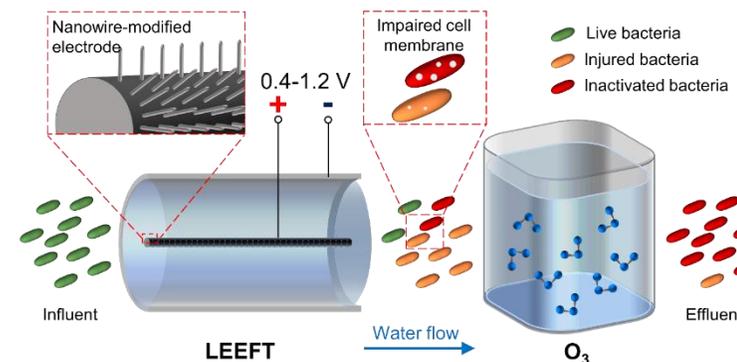
SYSTEM DESIGN: NANOWIRE-MODIFIED ELECTRODES



Cu
 CuO
 PDA



PROCESS DESIGN: LEEFT-O3



LEEFT

- **Low** energy consumption (~5 J/L)
- Relatively **short** electrode lifetime
- Mechanism: Electroporation on **cell membrane**

+

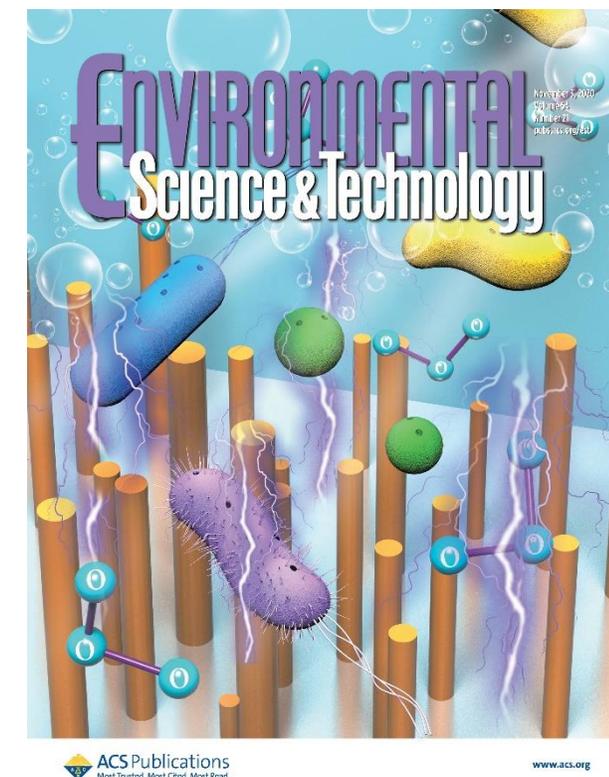
O₃

- **High** energy consumption (50-100 J/L)
- **High** effectiveness
- Mechanism: chemical oxidation of **cell membrane**



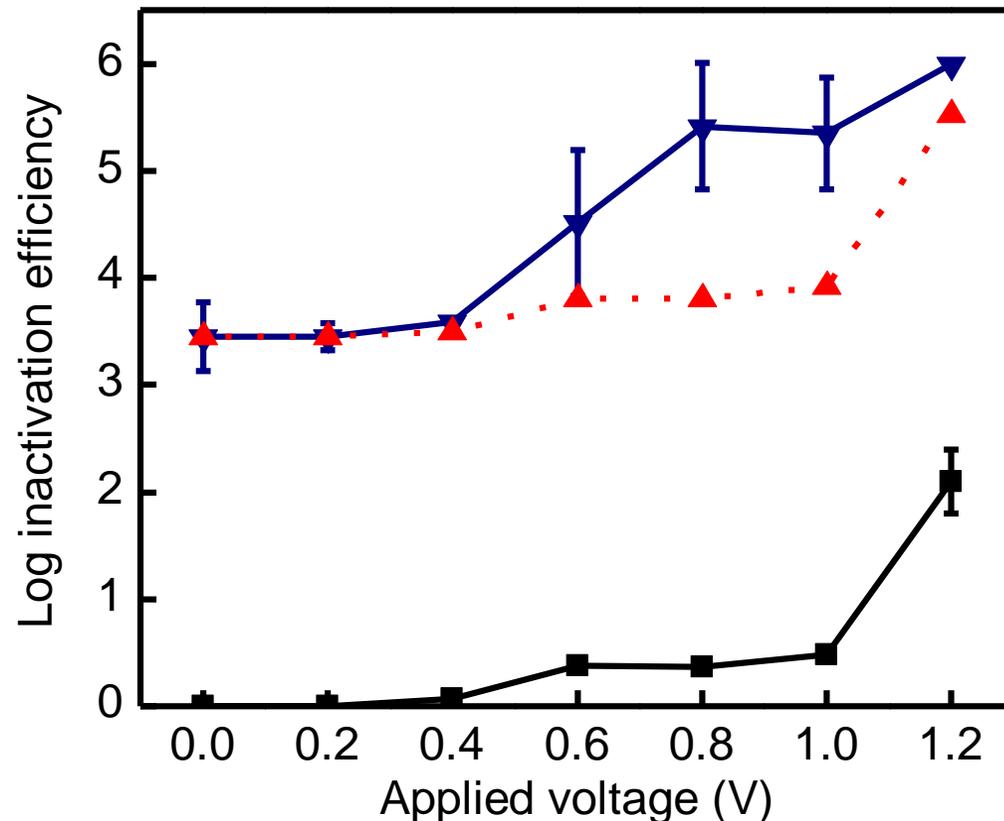
Coupled

- **Reduce O₃ dosage** by LEEFT pretreatment in order to **save energy**
- **Lower applied voltage** of LEEFT as pretreatment to increase the electrode lifetime
- **Enhancement effect** as both processes target on **cell membrane?**



PROCESS DESIGN: LEEFT-O3

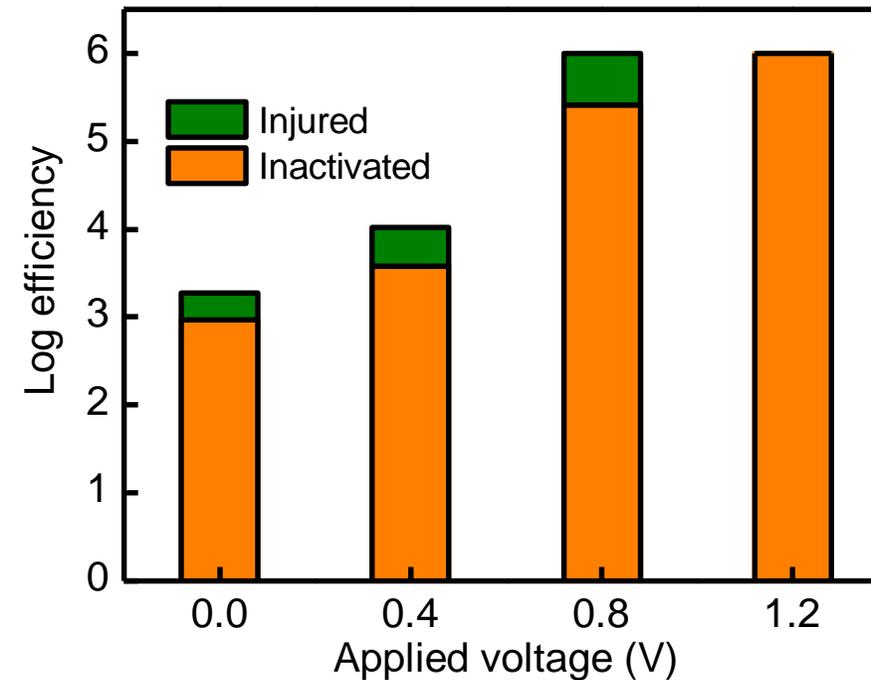
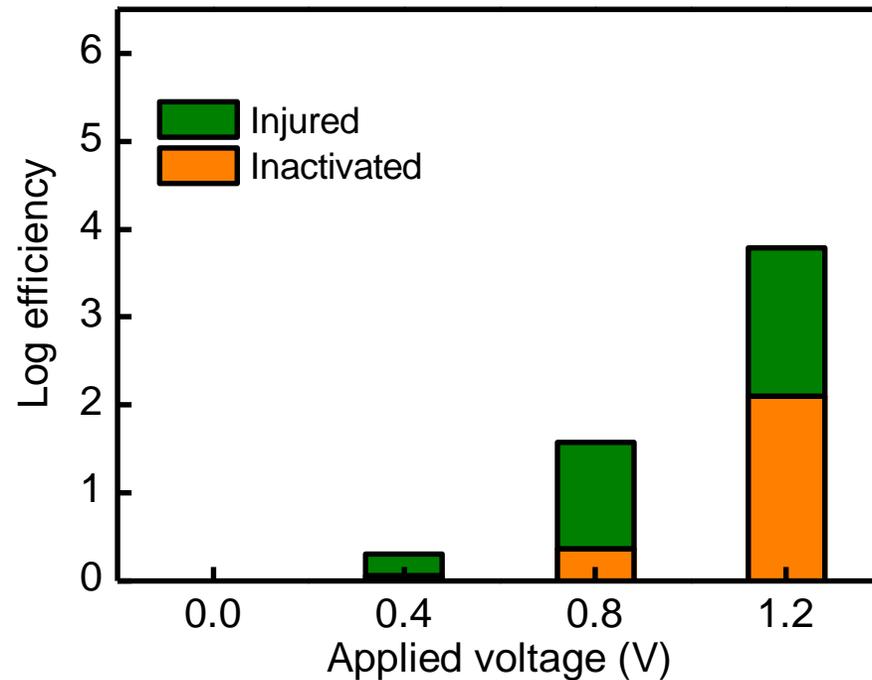
- The effect of **applied voltage** of LEEFT
 - The O₃ condition is fixed at 0.08 mg/L dosage and 2 min.



- **Low voltage** (0-0.4 V)
 - *Additive*
- **High voltage** (0.6-1.2 V)
 - *Enhancement*
- **LEEFT** can **promote** the inactivation efficiency of O₃

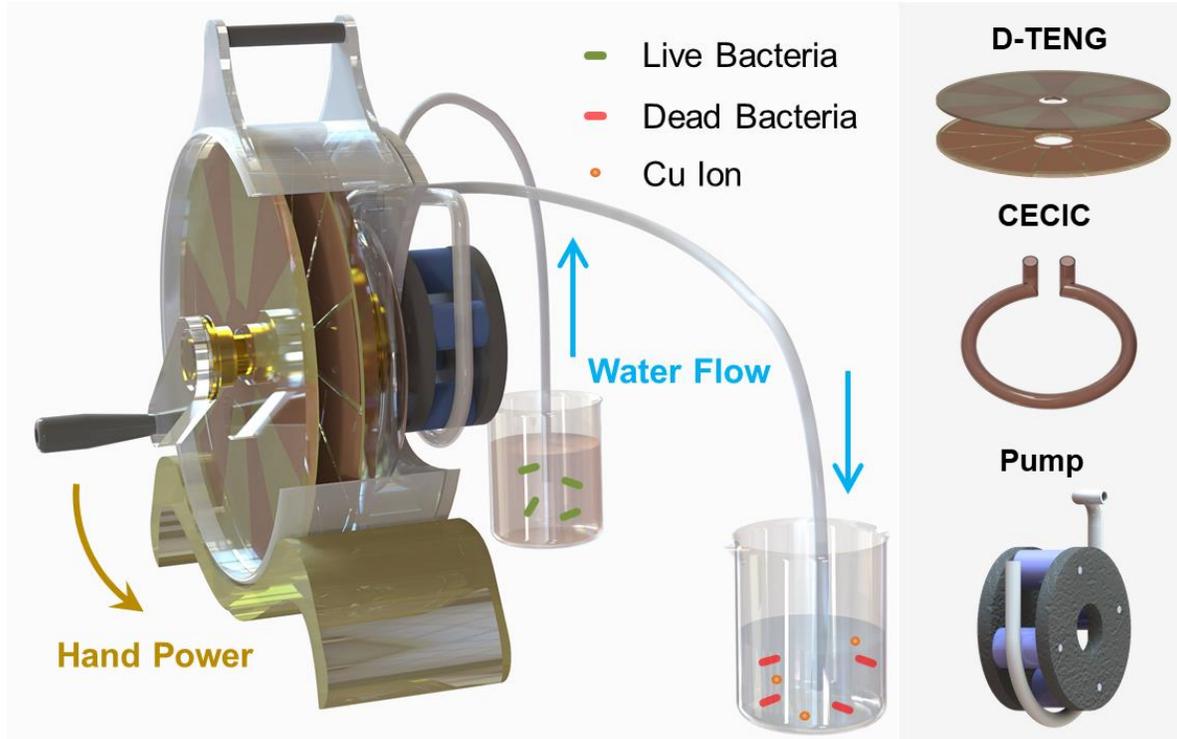
PROCESS DESIGN: LEEFT-03

- Mechanism study: **Sub-lethal** population due to **membrane damage**
- **Injured** and **Inactivated** efficiency of *E. coli*



- After **LEEFT**, a lot of bacteria are **injured** at 0.8 & 1.2 V.
- The injured population after O_3 is **low**.
- Similar phenomenon observed on *S. epidermidis* (G+).

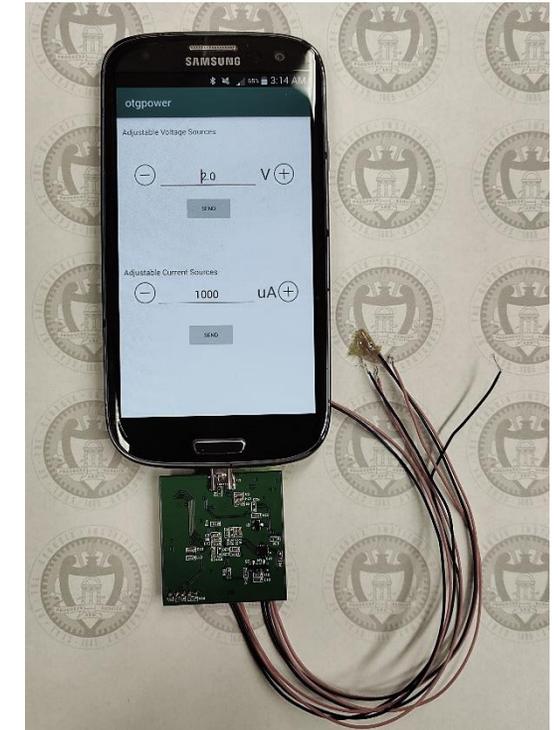
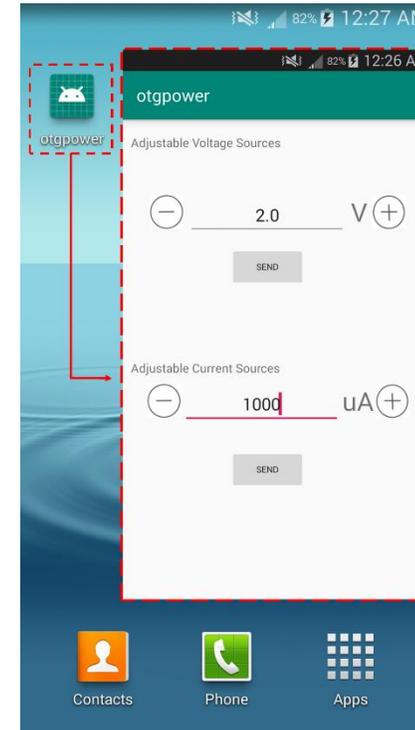
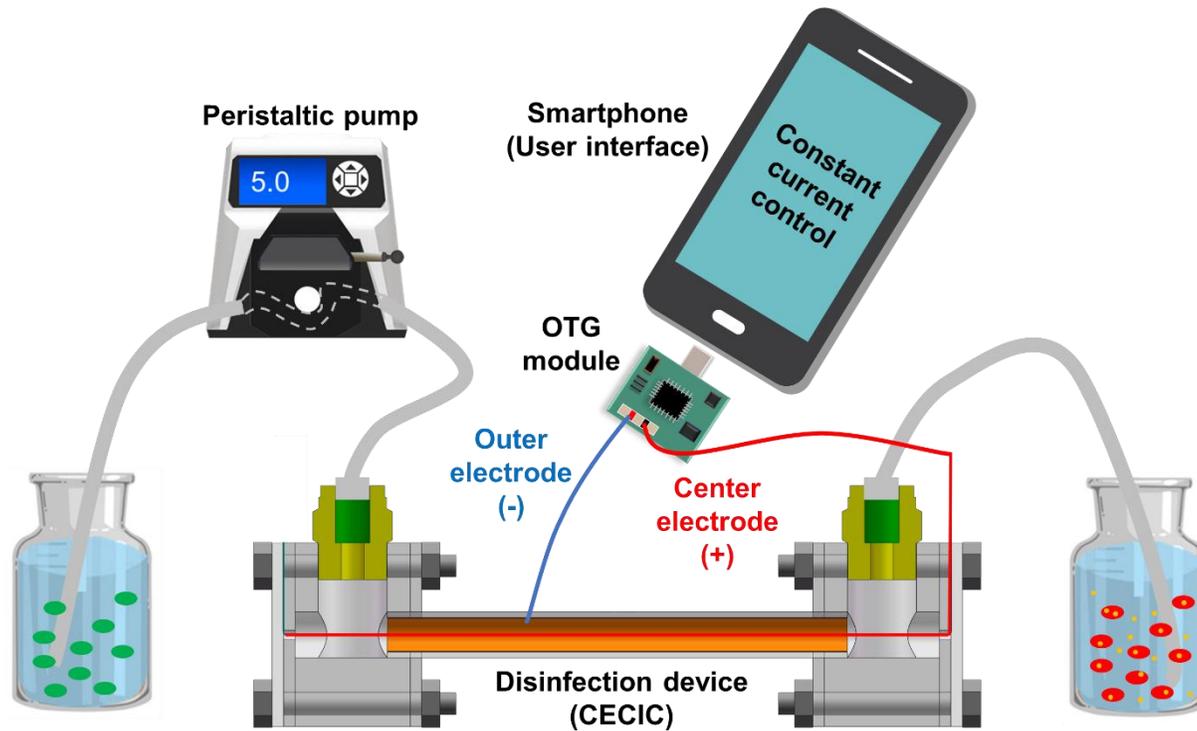
NOVEL ENERGY SOURCES



TENG-powered Disinfection at POU

- TENG = Triboelectric Nanogenerator
- POU = Point of Use

NOVEL ENERGY SOURCES

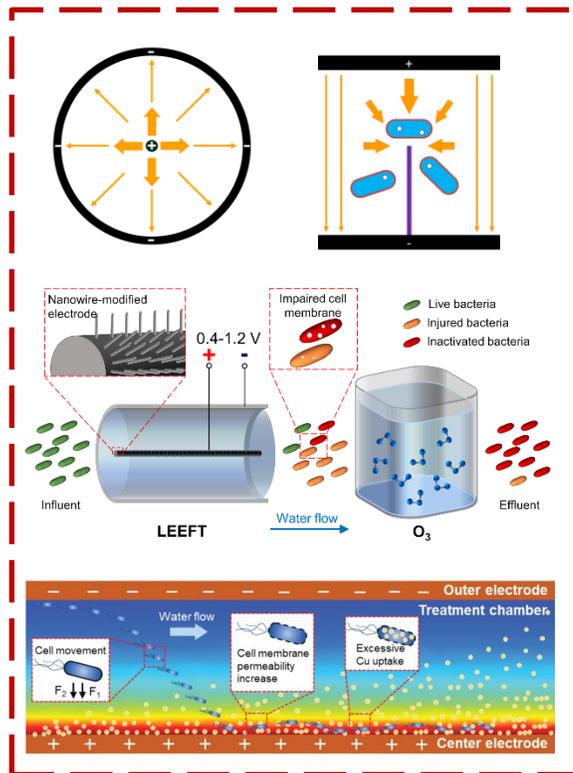


Smartphone-powered Disinfection at POU

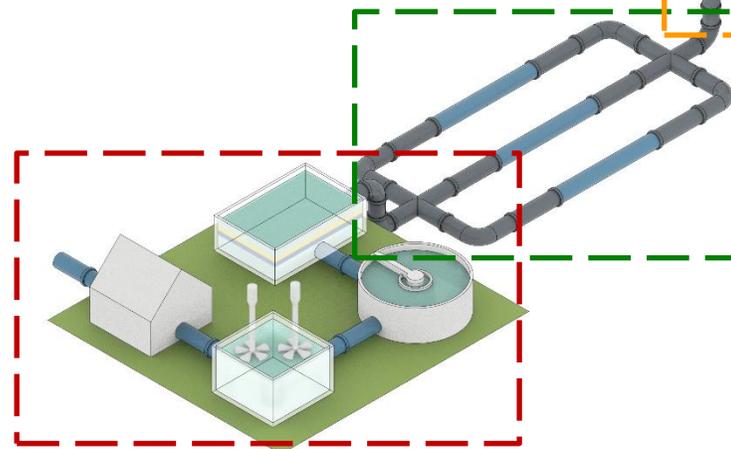
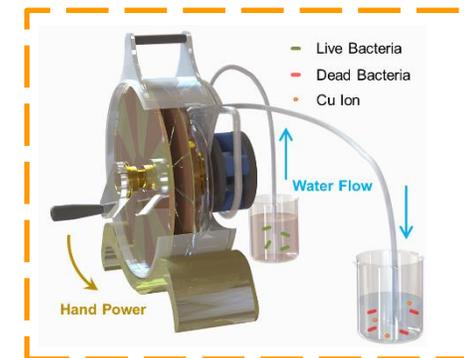
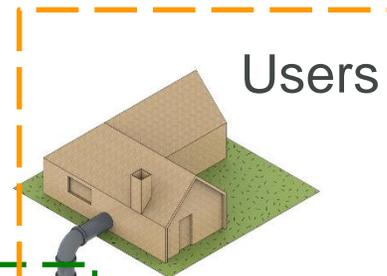
- POU = Point of Use

SUMMARY & IMPLICATIONS

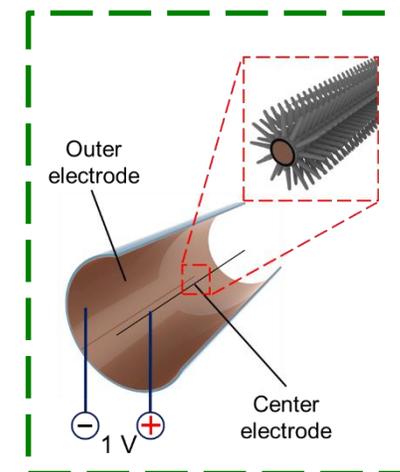
- Locally enhanced electric field treatment (LEEFT) for water disinfection
 - Physical** process, no disinfectant requirement, **no DBP formation**
 - Potentially be applied in **different scales** of disinfection



Water distribution system (Secondary)



Water treatment plant (Primary)



ACKNOWLEDGEMENT



Xing Xie group @ Georgia Tech



NWRI | National Water Research Institute



THANKS!

Questions & Comments?

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Georgia Tech Shenzhen Institute, Tianjin University (GTSI)

Adjunct Assistant Professor, CEE

Georgia Institute of Technology

2022.12.5

Poll, Final remarks & conclusion

MODERATOR: EMMANUEL MOUSSET

FEW TAKE HOME MESSAGES

- Several emerging technologies: UV-LED, electrochemical and electrical-based systems
- Need for suitable and sustainable disinfection technologies for long-term efficiency without DBPs issues
- Not one single technology will answer all disinfection issues
→ need for a solution toolbox to select and combine on a case-by-case basis

DISINFECTION WEBINAR SERIES 2022-2023



- Upcoming webinar(s): 1st semester of 2023
 1. Topic: Challenges and opportunities in identification, risk-based prioritization and control of DBPs in drinking water
 2. Topic: Emerging technologies for water and wastewater treatment (e.g. chlorine-related, ozone and organic peroxy acids systems)

UPCOMING IWA EVENTS

GET-TOGETHER

13 December 2022, 13:00 GMT



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PROFESSIONALS**

Lessons learned from COP27 and the 2022 Groundwater Summit



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