CONFIDENTIAL

June 2023

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ADVANCING NANOBUBBLE TECHNOLOGY

Selective Oxidation of Inhibitory Compounds




Problems Moleaer Solves in Wastewater Treatment

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Observed Benefits with Nanobubble Pretreatment

Primary Clarifier	Aeration	Secondary Treatment	Anaerobic Digestion	Disinfection
				
Up to 10% more solids removal	**Up to 43% less energy required**	**Up to 20% more treatment capacity**	**Up to 98% increase in biogas production**	**Up to 44% less chlorine demand**

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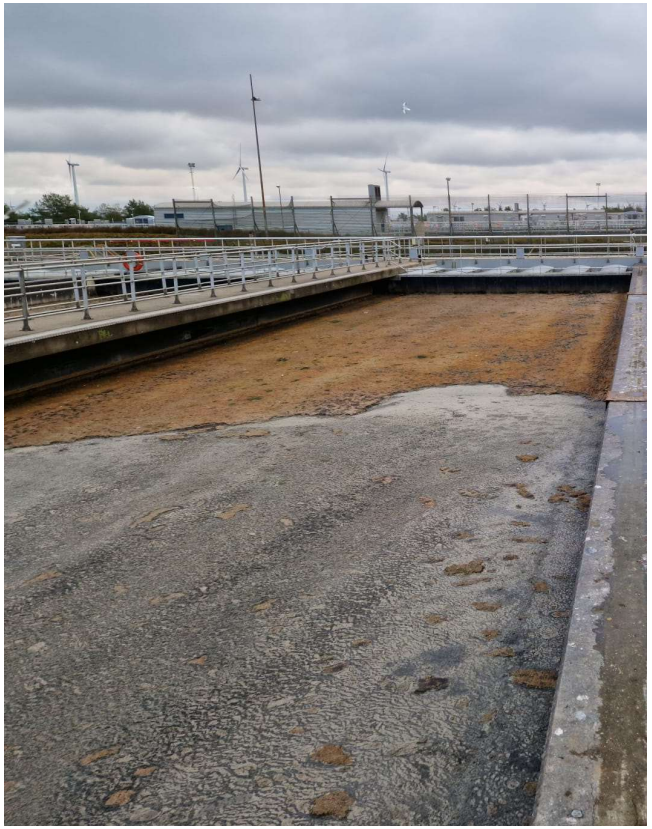
The Root Cause

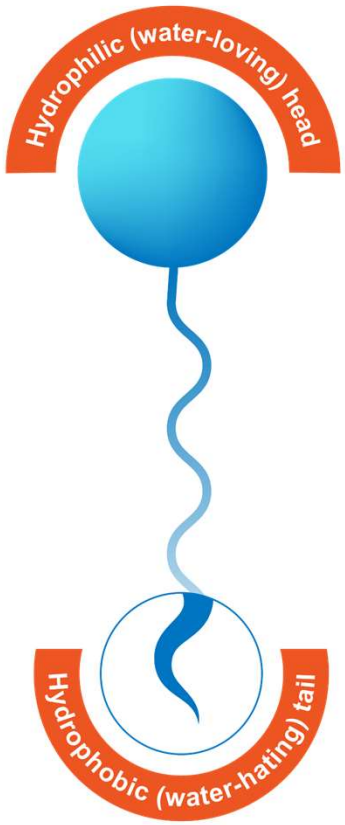
Inhibitory Compounds:

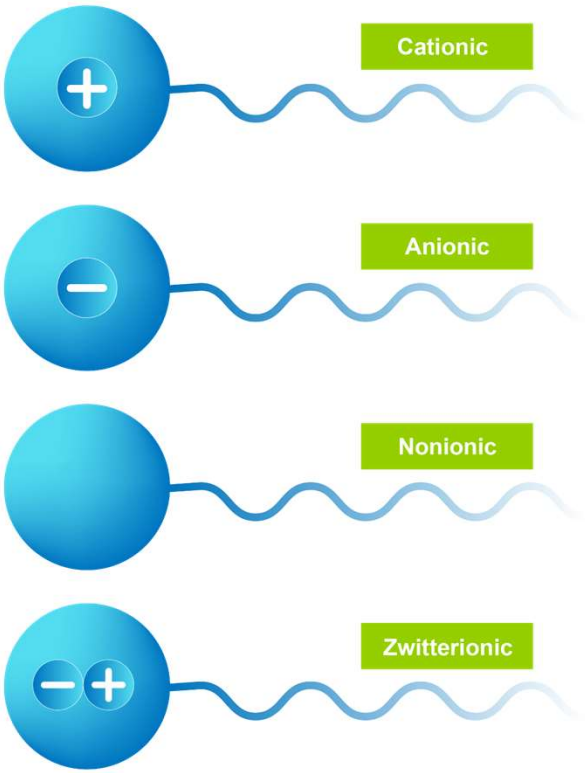
- Fats, Oils & Grease (FOG)
- Surfactants:
  - Soaps/Detergents
  - Quaternary Ammonium Compounds (QACs)
    - BACs & Others
  - Tensid
  - Tensioactif



- Inhibitory compounds interfere with solids separation, biological processes and oxygen transfer (OTE_f, OUR, & OTR)
- Makes wastewater harder and more **<u>expensive</u>** to treat

Inhibitory (Amphiphilic) Compounds





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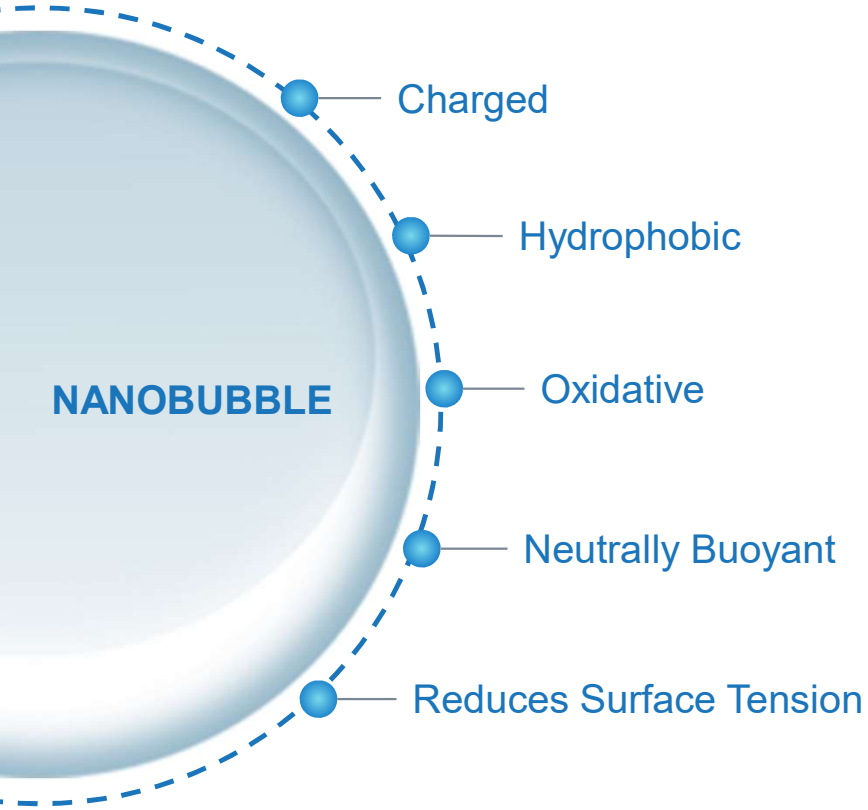
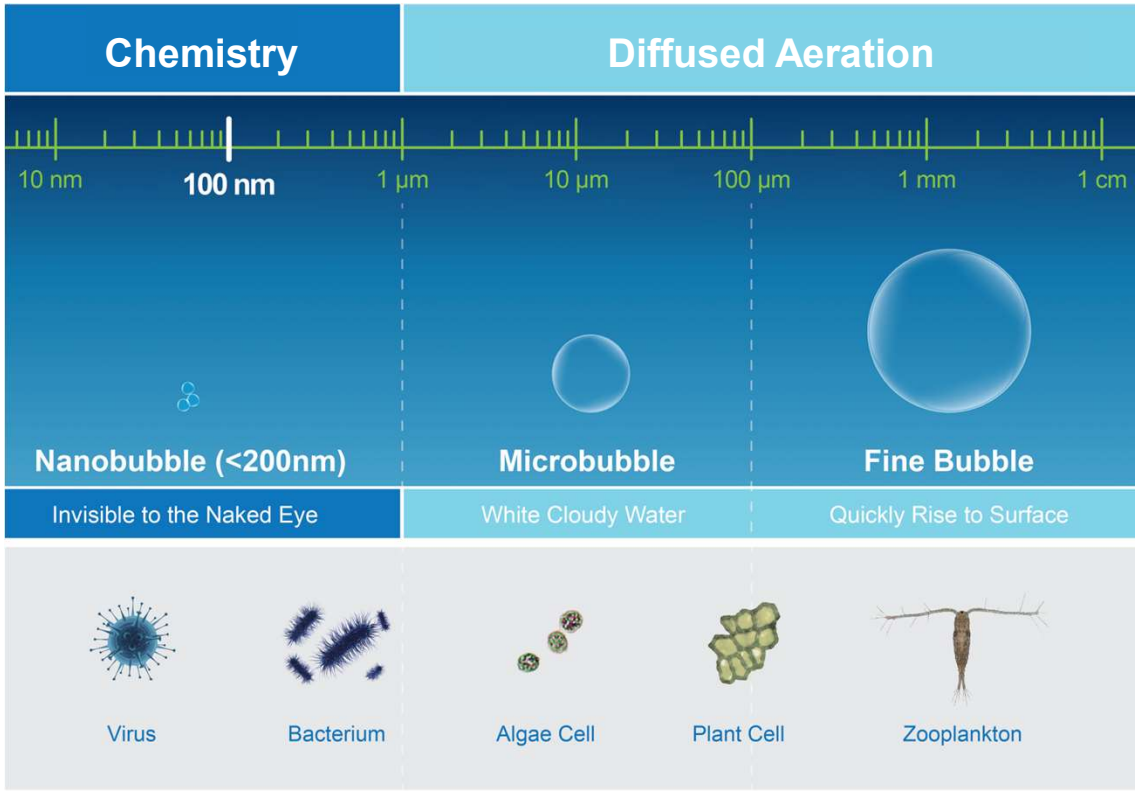
Nanobubbles for Wastewater

A form of chemistry that can enhance physical, chemical, and biological reactions





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Nanobubble Chemistry Does NOT Replace Aeration

Traditional Wastewater Aeration

- Fine bubble, coarse bubble, & surface aeration
- Part of activated sludge/secondary treatment process
- Adding air into wastewater to allow aerobic biodegradation of organic materials

Nanobubble Chemistry

- Nano-sized bubbles act like chemistry
- Commonly used as pretreatment
- Chemistry that breaks down inhibitory compounds before they reach process units
- Increases treatment process efficiency and capacity while reducing chemical and energy consumption

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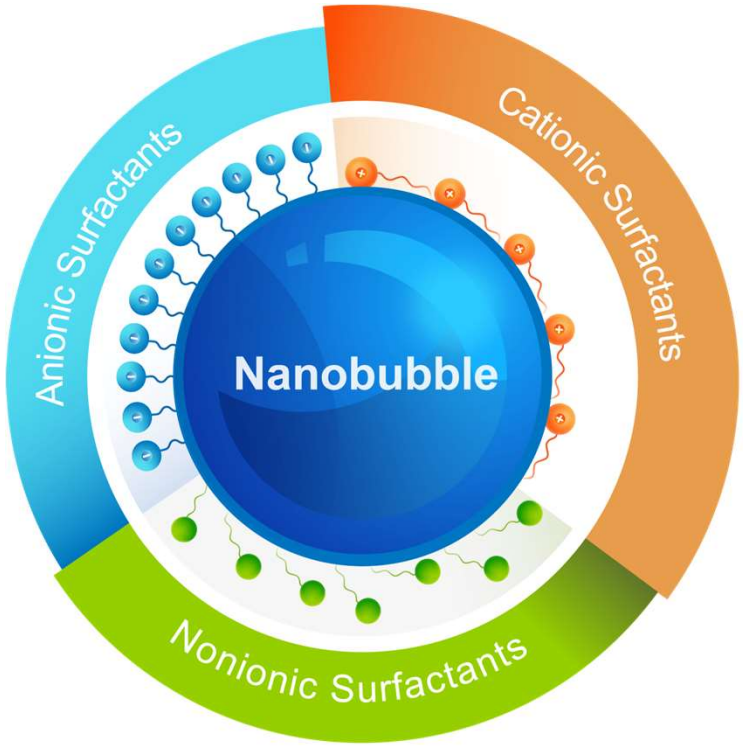
Clean Chemistry Breaks Down Inhibitory Compounds

- Amphiphilic molecules have a hydrophobic head that attracts water and a hydrophobic tail that repels water
- Absorb at air/water or oil/water interfaces
- Accumulate at the surface of bubbles and oil droplets in water
- Align with head in water and tail in air (or oil)
- Breaks down inhibitory compounds through clean chemistry
- Makes wastewater easier to treat



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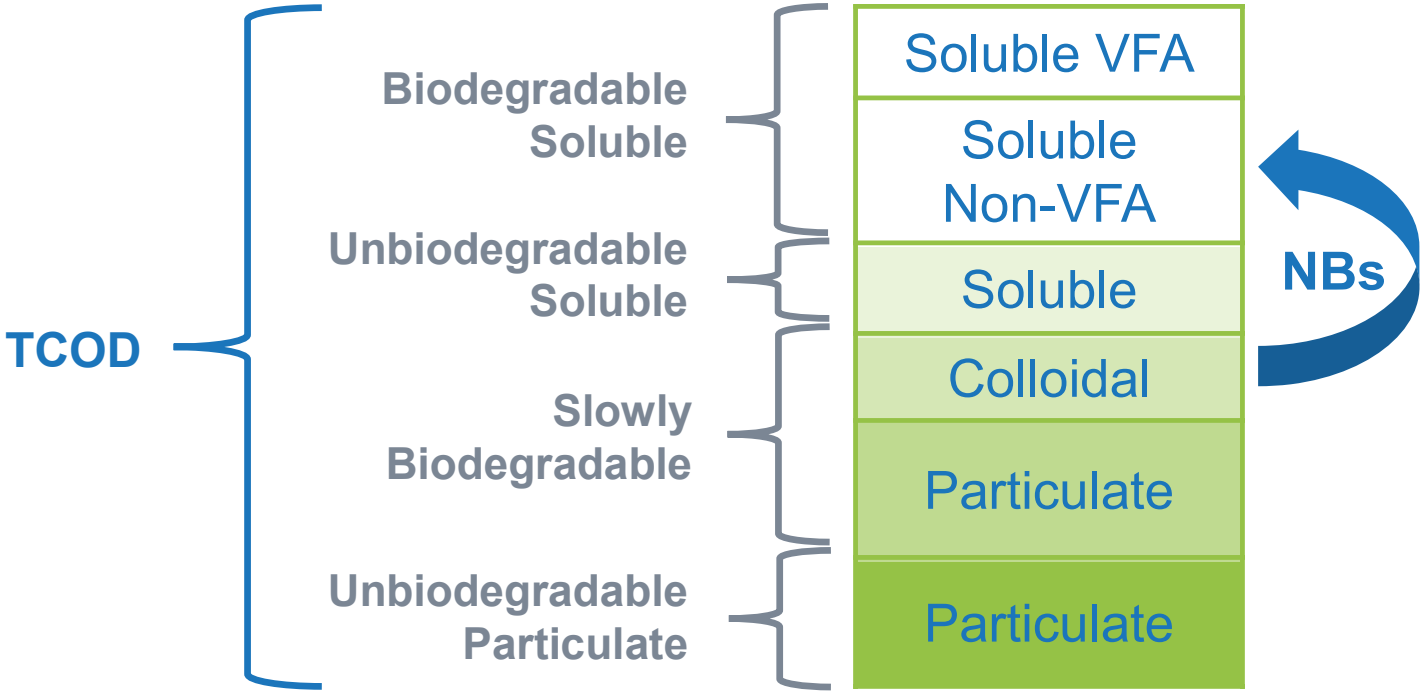
How Do Nanobubbles Act on Influent COD?



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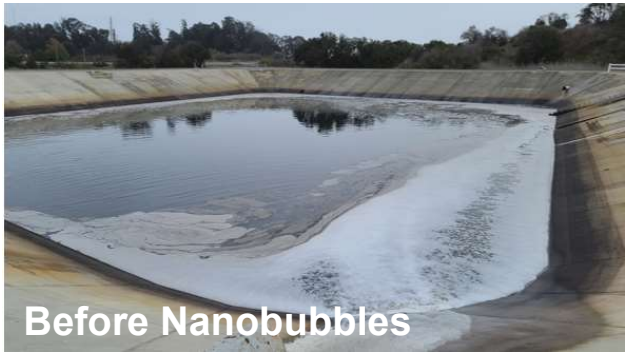
Visible Changes: Less Scum, Less FOG, and Less Foam

Primary Clarifiers
Copenhagen, DK

Equalization Basin
Goleta, CA, US



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Municipal Wastewater Treatment – Scalable Solution

Stavnsholt WWTP

Location: Denmark

AADWF: 0.7 MGD (108 m^3/hr)

BOD_5: 500 mg/L

Results:

- Reduced odors (Primary Goal)
- **15% increased settlement**
- Reduced ferric usage
- Higher biogas quality

Goleta WRRF

Location: United States

AADWF: 4.2 MGD (662 m^3/hr)

BOD_5: 450 mg/L

Results:

- **43% reduction in aeration energy**
- **44% decrease in chlorine demand**
- **20% increase in secondary treatment capacity**
- **10% increase in primary clarifier solids removal**
- Eliminated odors, foam, and the need for bioaugmentation

Lynetten WWTP

Location: Denmark

AADWF: 20 MGD (3,144 m^3/hr)

BOD_5: 450 mg/L

Results:

- **15% increase in secondary treatment capacity (Target – 10%)**
- Significant reduction in scum accumulation on primary clarifier

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Scalable & Flexible Solution

	NBG 3	NBG 4	NBG 6	NBG 8
Liquid Flow Rate, GPM (m^3/hr)	300-550 (68-125)	600-1100 (135-250)	1300-2600 (295-590)	2600-4700 (590-1065)
Recommended Gas Flow* SCFH (SLPM)	150 (75)	300 (140)	550 (260)	825 (390)
Est. Power Draw, BHP (kW) Submersible/Suction Lift Pump	8/13 (6/9)	18/28 (13/21)	42/64 (31/48)	72/111 (54/83)
SOTR with Air** O_2 LB/day (KG/day)	30 (14)	63 (28)	108 (49)	151 (69)

* at 60 PSIG (4 barg)

** Not a replacement to aeration - NB technology provides <1% of the total process oxygen demand for a typical facility

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Nanobubble Technology Installation Examples

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Nanobubble-as-a-Service Option

- No upfront cost
- Immediate ROI
- Can integrate inline with an existing pump
- Minimal maintenance
- In-situ clean chemistry with just air
- Upgrade to the latest technology

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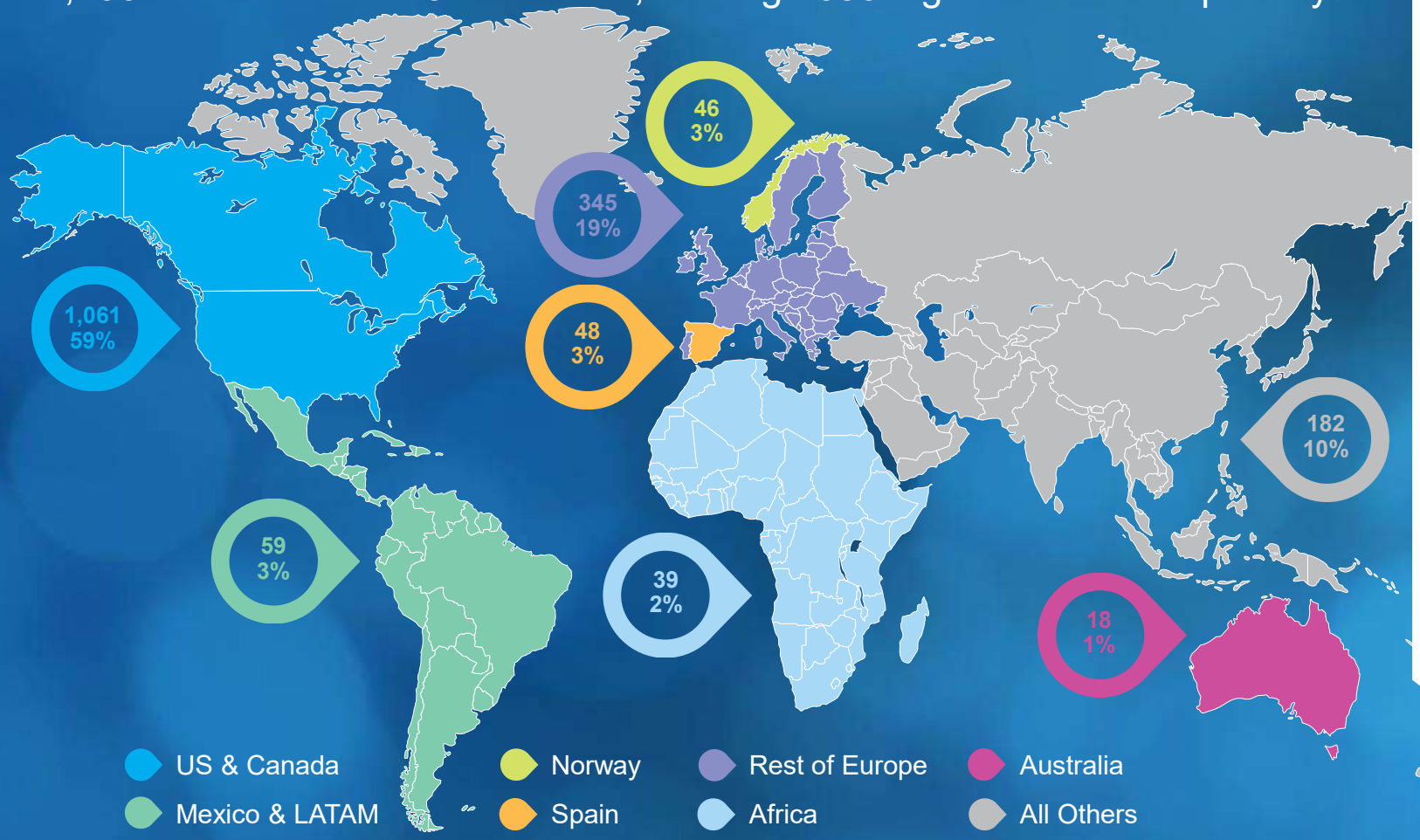
The Global Leader in Nanobubble Technology

>2,400 installations in >51 countries, treating >650M gallons of water per day



Our Mission:

Unlock the power of water to do more with less

- 9 patents
- >80 employees
- Award-winning technology
- Third-party validation

UCLA

VIRGINIA TECH

ASU Arizona State University

GLOBAL CLEANTECH 100 2022

Real Leaders Impact Awards 2022

FAST COMPANY Next Big Things In Tech 2022

GLOBAL WATER AWARDS 2022

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Thank You!

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