

Details of the Pilot

- Name of Client: **Kooler Industries Inc.**
- Location: **Philippines; eight regional distribution & service centers providing national coverage**
- Application: **Point-of-Use integration into drinking water fountains and under-counter water purifier systems**
- Flow Rate: **2 L/min**
- Influent & Effluent Spec: **Influent is municipal tap water or river water in remote communities, and effluent is drinking water safe for consumption.**



Drinking water purification at point-of-use protects people from contamination that can happen anywhere between water treatment facilities and consumption. Known sources of water contamination in the Philippines include aging, unmaintained or leaking water pipes, sludge buildup in water tanks, poor handling at water bottle refilling stations, as well as sun exposure and improper handling of bottled water.

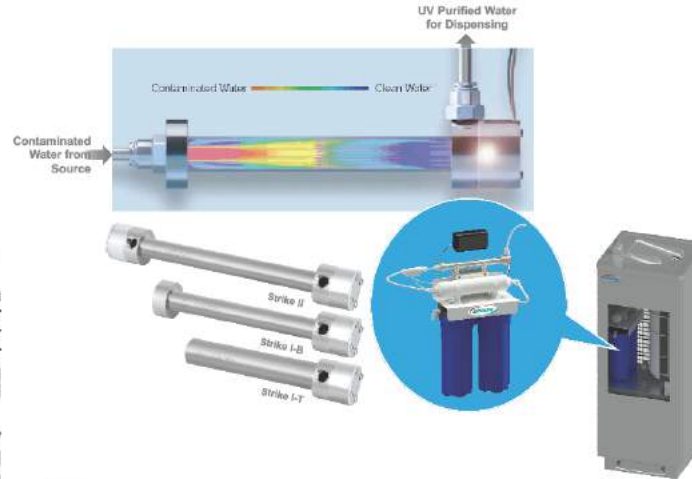
Kooler Industries Inc. combines multi-stage filtration with UV disinfection to ensure elimination of particles, chemicals, and bacteria to protect health and safety with high-quality drinking water for their customers. UV energy eliminates any microbial contaminants left behind by filters to make water safer to drink.

With added UV-LED disinfection confidence, Kooler is expanding its product offering to include off-grid solar water purifier units and wall-mounted models, as well as home and countertop purifier systems in the Philippine market.

Compelling Value Proposition

True to Kooler's spirit of innovation, the company met with Acuva in search of ways to further improve their product design. UV-LEDs were the ideal progression for their product lines with its added advantages over their existing systems with UV-Lamps, including:

-  **Lower power and maintenance costs;** UV-LED replacement only needed after 5 years of use as opposed to yearly UV-lamp replacement
-  **Provides sustained high-performance disinfection,** always passing microbial tests. Failed microbial tests resulted in fines for Kooler
-  **Proven performance of UV disinfection is a chemical-free water purification technology** that does not risk mercury or PFTE contamination
-  **Solar-compatible** and uses significantly **less power** than legacy lamp systems, allowing for applications that were not possible in the past
-  **UV-LEDs do not add any heat,** ensuring dispensed water is always refreshing and cool to drink
-  **Contains no Mercury or single use-plastics;** is built with UV-safe infinitely recyclable stainless steel material



The UV-LED Integration Experience

Making the move from UV-Lamp to UV-LED helped Kooler achieve lower lifetime cost of ownership for leased systems, while giving their brand the added benefit and differentiation of high-performance UV-LED disinfection. Investment in this new technology pays back after 2-3 lamp service cycles (not taking into account labour, proper lamp disposal, and fines associated with failed water tests.)



Service Instance	1	2	3	4	5
UV-Lamp Cost	\$59.55	\$76.40	\$101.87	\$127.33	\$147.18
UV-LED Module Cost	\$45.00				
Direct Savings to Kooler	-\$14.55	\$31.40	\$56.87	\$82.33	\$102.18

UV-LED reduces maintenance part expenditures which provide Kooler a cash-positive benefit earlier than 12-20 months. The upgrade lowers the amount of service calls while eliminating nuisance lamp failures that often involve shattered glass and potential for mercury contamination. Each module, tailored to Kooler's unique application requirements, effectively disinfects 1.2 million litres of drinking water in its lifetime. Installation of module right before point of dispensing ensures microbial tests are passed, while protecting health & safety.

What Problems Did UV-LED Solve for Kooler Industries?

Existing UV-Lamp systems were effective but were not without challenges. This included added heat, high power consumption and maintenance requirements like lamp replacement that resulted in downtime of the system.

Integration of long-lasting UV-LED modules resolved all of these challenges while providing high-performance disinfection. In addition, decommissioning their UV-Lamp systems eliminated any potential mercury emissions or contamination to align with the UN Minamata Convention.

Adoption of UV-LED provided Kooler with a key differentiator in the Philippine market, increased market share, and aided in the development of new products made for remote and off-grid communities. Testing of river water treated with Kooler's first generation prototype proves viability for portable solar systems:

Test Results: River Water Sample

Parameter	Result	Unit	Limit	Remarks
Fecal Coliform	2,200	MPN/100 mL	200	Control
Heterotrophic Plate Count (HPC)	825	CFU/mL	—	Control
Total Coliform	5,400	MPN/100 mL	—	Control

Test Results: Treated River Water (Safe to Drink)

Parameter	Result	Unit	Limit	Remarks
Fecal Coliform	< 1.1	MPN/100 mL	< 1.1	PASSED
Heterotrophic Plate Count (HPC)	7	CFU/mL	< 500	PASSED
Total Coliform	< 1.1	MPN/100 mL	< 1.1	PASSED

This enabled Kooler to grow their business, optimize their total cost of ownership and capture the growing drinking water purifier market in the Philippines.

What UV-LED Drinking Water Modules Mean for the Future

Acuva's fully customizable, high-performance UV-LED reactor design can be adapted to meet any water or ice appliance manufacturer's requirements. Residential use is where the most growth can be realized. This technology helps reduce the need for single-use plastic water bottles at the source and can provide safe drinking water to any community in the world, empowering decentralized drinking water treatment systems.

The compact form factor of Acuva's UV-LED module allows for smaller-sized appliances that allow for portability and access to safe drinking water in remote and infrastructurally-challenged regions both for regular use and disaster relief situations. In addition, advanced UV-LED integrations have already been tested and integrated into pharmaceutical and ultra-pure lab water devices.

From WWTP to biofactories

Details of the demo / pilot

Name of client: Municipality of Chiclana de la Frontera

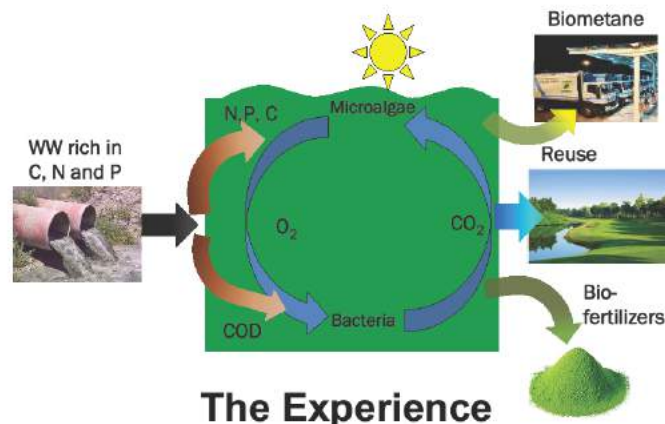
Location: Chiclana de la Frontera

Application: Wastewater treatment, biogas upgrading and biomass valorization

Flow rate: 2100m³/d of pretreated wastewater
 Influent and effluent spec

Parameters	Influent	Effluent
F (m ³ /d)	1000	950*
TN (ppm)	46.4	12.1
TP (ppm)	8.3	1.1
COD (mgO ₂ /L)	500	101.1
TSS (mg/L)	210	22.0

Allgas project is an pre-industrial facility to demonstrate feasibility of treating the WW in high rate ponds with symbiotic interaction between **microalgae and bacteria**. The main objective is to reduce energy consumption and increase removal efficiency.



The Experience

To avoid the risks associated to the scale up of the process, aqualia started with **basic research in 2010** and scaled up carefully to minimize the risk until the final **Demonstration plant in 2017** (2,1hectares). In 2019 we will build another **5Ha facility**



The challenges will be focused in reducing the land required to implement the process, currently around **1,8m²/PE** being the target **1m²/PE**.

With regard to the All-Gas approach an **EROI (Energy returned on energy invested)** of approx. 2 is calculated which means that the system has a positive energy balance

What problem did this aim to solve?

- Transform WWTP from high energy consumers to **bioenergy factories**
- Reduce energy requirement for treating wastewater, consumption **below 0,2kWh/m³** of water treated
- Increase TN and TP removal efficiency in a single stage reactor
- Natural wastewater **disinfection**
- Produce **valuable algae/bacteria biomass**
- **Stop burning** biogas in the torch
- Avoid O₂ consumption in WWTP



* Evaporation

What was the compelling value proposition?

- Lower **Capex and Opex** in WWTP. Energy requirement will be reduced from 0.5 to less than 0.17kWh/m³
- Increase **simultaneous nutrient removal** efficiency, below 10 ppmTN and 1ppm TP
- Reduce **chemicals**
- Produce a valuable algae/bacteria biomass, **rich in N & P** as well as valuable **amino acids profiles**.
- **Upgrade** raw biogas to a vehicular biomethane (>90%CH₄).
- **Disinfection** of wastewater at negligible energy consumption
- **Easy process** without external or/and internal recycling.
- **No need** of externa C addition.
- A high rate **dissolved air flotation** unit is used to harvest the biomass efficiently, with an energy requirement below **0,04kWh/m³**.

What this means for the future?

How many similar applications are there out there?
 Aqualia is running **3 different demonstration in Spain** plants, and we are planning to start before the end of 2019 another 5hectreas plant in South Spain. In the United States and New Zealand there are several similar plants, although the operation mode and process design is different than the developed by aqualia.

How easy will be to replicate this success?
 The technology developed is **highly replicable**, the efficiency of the process will depend mainly on weather conditions, since the process depends on **photosynthetic efficiency**.



AVMD» ADVANCED VACUUM MEMBRANE DISTILLATION

DETAILS OF THE DEMO

In AVMD, a vacuum is created to pull water vapor through the membranes, while the brine is continuously recirculated. Salt crystals are kept away from the membranes as they grow, thus eliminating the need for a crystallizer. This technology has been tested for a variety of Zero Liquid Discharge (ZLD) & Minimal Liquid Discharge (MLD) applications, with pilot results for TDS, selenium and COD removal included in this study. The three pilots were operated for more than 30 days each, with challenging wastewater usually requiring conventional thermal evaporation techniques to treat.

Industries Tested: Brewing (I), Power (II) and Pharma Manufacturer (III)

Application Types:

- Thermal evaporation for RO reject with very high TDS (I)
- High TDS FGD from coal-based power plant for selenium reduction (II)
- Pharmaceutical Wastewater with high COD unable to be removed efficiently with other processes (III)

Operating Flux: >20 LMH

Membrane Surface Area: Up to 5 m²

THE AVMD VALUE PROPOSITION

AVMD delivers unmatched value for:

• Challenging Treatment Applications

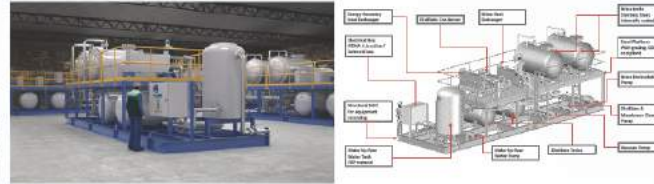
- 40 - 50% CapEx advantage over conventional technologies due to reduced complexity and subsequently lower capital costs
- Meets compact footprint requirements via modular configuration

• Consistent High Performance

- Delivers 2x the flux of competing MD technologies (>20 vs 10 LMH)
 - Steady product quality regardless of feed brine concentration, with recovery > 90%
- Elimination of fouling through innovative vapor-phase design preventing contact between liquid/brine streams and membrane.

• Energy/Resource Savings

- Especially if waste heat or solar energy is available onsite
- Recoverable solvents can be recycled back to an upstream industrial process



Left: Overall AVMD system skid / Right: Component diagram with skid

THE EXPERIENCE

In each pilot program, the AVMD provided consistent performance without fouling while exceeding energy sustainability goals.

- High effluent quality with >35% total solids content produced in the RO Reject study. Nearly 99.9% TDS reduction as well. (I)
- Treated Se in FGD blowdown to 5 ppb compliance value suitable for recycle or discharge. (II)
- COD Removal greater than 99.5% in pharmaceutical study. (III)
- Membranes were highly temperature resistant in all cases, being able to withstand up to 90° C.

	Pilot I	Pilot II	Pilot III
Application	RO Reject	FGD	Pharmaceutical
Target Parameter	TDS	Selenium (Se)	COD
Influent Quality (ppm)	71,500	5	30,000
Distillate Quality (ppm)	100	<0.01	<150



Left: Crystals removed in RO brine treatment
Right: Undissolved salt in brine water (@80 °C)

LOWER CAPITAL COST ↓ **2X HIGHER FLUX**

NO MEMBRANE FOULING

CONSISTENT DISTILLATE QUALITY

WHAT PROBLEMS ARE SOLVED

Increasing regulations and pressure for industries around the world to achieve ZLD / MLD highlight a growing need for innovation in brine management technologies. Currently, conventional thermal evaporation technologies are unable to provide low cost solutions for customers due to high installation and maintenance complexity.

As a globally-recognized leader in ZLD with over 200 installations, Aquatech has consistently innovated thermal and membrane technologies to help clients meet their water and financial savings goals. Aquatech's Advanced Vacuum Membrane Distillation (AVMD) uses modular configuration and proprietary vapor-phase design to substantially drive down total cost of ownership for clients with brine management needs. Furthermore, AVMD is an unprecedented technology presenting a distributed, cost-effective solution to ZLD & MLD facilities for the first time.

AVMD'S POTENTIAL

This versatile technology can be applied to industries including Chemicals, Food & Beverage, Pharmaceutical, Oil & Gas, Microelectronics, Data Centers, Manufacturing, Automotive and Landfill Leachate. AVMD is highly disruptive due to its fundamental design advantages and Aquatech's extensive experience in thermal and membrane solutions. It offers additional value due to its competitiveness in both small and mid-scale crystallization applications. The potential market size of this technology is more than \$100M based on the applications tested.

Decentralised Sanitation and Reuse (DeSaH)

DeSaH B.V.
www.desah.nl
b.meulman@desah.nl

Details of the project

Decentralized treatment plant, based on source separation, for black (BW) and greywater (GW) of 350 people in Sneek, The Netherlands. Operational since 2011.

In total 35 m³/d of BW and GW is treated with a focus on energy reclamation (biogas and heat), phosphate recovery and very high removal efficiencies.

Since BW is highly concentrated (12 g COD/L, 1.5 g N/L, 0.2 g P/L) treatment technologies like anaerobic digestion (UASB), annamox (OLAND) and struvite precipitation can be used.

Very high removal efficiencies of more than 90% are reached for COD, Nitrogen and Phosphorus



What problem did this aim to solve?

The concept addresses multiple issues, like:

1. Water saving
2. Energy production
3. High removal efficiencies for COD, N and P
4. Nutrient recovery

The concept demonstrates the combination of a net energy positive wwtP that recovers nutrients but also has the ability to produce reusable effluent.

What was the compelling value proposition?

The concept was introduced as alternative to:

1. Existing decentralized treatment technologies like:
 - a. constructed wetlands, but with much less surface area required, better effluent quality and nutrient recovery
 - b. membrane bioreactors, but much less energy required, lower operational costs and nutrient recovery
2. Conventional centralized wastewater treatment, but much more flexible due to smaller scale, energy producing, no chemicals used and less sludge production.

The Experience

Extensive evaluation of the project has shown that compared with conventional centralized wastewater treatment at a scale of 100.000 P.E the DeSaH concept:

1. Will have similar OPEX (including depreciation) at a scale of 3000 people, if the scale will be increased it will outcompete conventional;
2. Will produce 200% more energy than an energy optimized centralized wwtP;
3. Will recover 250% more phosphorus than the current state of the art;
4. Will produce 2x times less surplus sludge, with much higher quality due to lower heavy metal concentrations;
5. Will save 30% of potable water;
6. Footprint is about 0.2% of the total footprint of the connected houses

What this means for the future?

The following reference projects are built / under construction:

1. Run4Life: European project with 15 partners and 4 demo sites that at multiple locations demonstrate the DeSaH concept. H2020, GA730285
2. Rijnstraat 8, office building in The Hague for 3500 employees
3. H+, housing estate for 2200 people in Helsingborg, Sweden
4. Waterwerkx, housing estate with 500 houses in Edmonton, Canada
5. Villa Flora, office building in Venlo, NL
6. NIOO, office building in Wageningen, NL

Focused Electrode Leak Location (FELL) ASTM F2550-18

Project Details

Client: Major US City Municipal Utility

Goals: Verify Pipeline Rehabilitation Effectiveness & Evaluate Pipeline Rehabilitation Priorities

Summary: Over 12M USD were invested to install 40,500 meters of Cured-In-Place Pipe (CIPP) for both mainline & lateral rehabilitation. An 80% reduction in infiltration (water entering a pipe through a defect) was projected, but measured reduction was <30%.

Defects Based on OPRI 1-5 Rating



Legacy

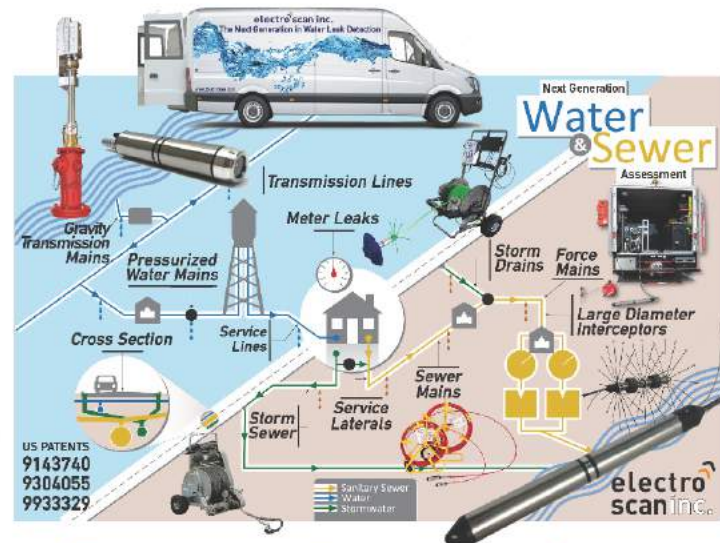
Acoustic Sensors (Water) & CCTV (Sewer) Miss Major Leak Locations

Defects Based on LPS (Litres Per Second)



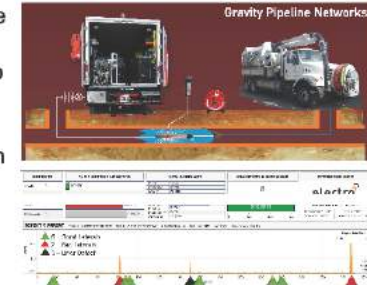
Machine

Low Voltage Conductivity Pinpoints Leaks by Main, Lateral, & Connection



The Problem & Solution

Legacy CCTV pipeline inspection methods continue to be used to apply human-based condition codes that establish rehabilitation priorities.



FELL - a proven, machine-intelligent, repeatable data collection process - eliminates human bias in documenting actual pipeline defect conditions that contribute to inflow & infiltration. This is done by using electrical current to locate (within 1cm) and quantify (in LPS) all defects with a pathway to ground. If the pipe leaks electricity, it will leak water.

The precise and quantifiable data generated by FELL technology allows utility Owners to optimize capital spending programs.

Compelling Value Proposition

1. **Savings 15 X Multiplier**, \$5 deferred maintenance, \$4 not accepting poor rehabilitation, \$3 Not selecting wrong pipe to fix, \$2 Heads-Up location of pipe damage, \$1 Pumping and Treatment costs.
2. Verify that work completed conforms to contract water tightness requirements to reduce infiltration.
3. Use real-time inspection results prior to contractor demobilization to support contract compliance.

The Experience

1. City consultant used closed circuit television (CCTV) inspection & overall pipe rating index (OPRI) scoring to develop rehabilitation priorities.
2. CCTV was also used to conduct post-rehabilitation effectiveness; however, incomplete video evaluations allowed contractors to be paid for poor quality work.
3. Flow monitors were used to further evaluate CIPP effectiveness, documenting *less than 30%* infiltration reduction achieved.
4. Partial FELL inspection allowed City to compare actual defect locations and flow rates to CCTV inspection results.
5. FELL inspection work verified inability of CCTV technology to prioritize rehabilitation program or validate contract compliance.

The Future

1. Comprehensive FELL inspections establish unbiased rehabilitation priorities for mainlines & laterals, avoiding unnecessary capital spending.
2. Repeatable & unbiased data collection and use is compatible with software applications for asset management, geographic information system (GIS) databases, hydraulic models, & related financial systems.
3. Provides utility Owners with precise pipeline defect condition information & infiltration flow rates before & after rehabilitation to document effectiveness.



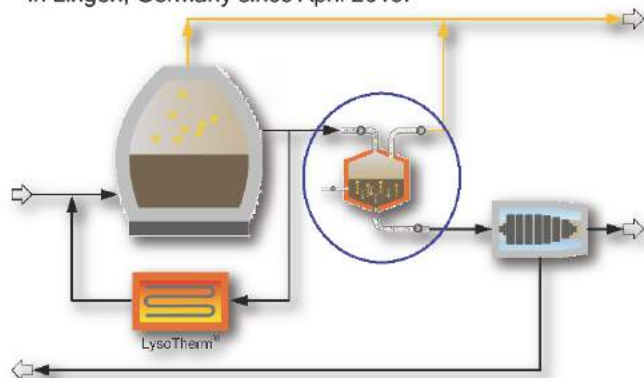
ELIQUO WATER GROUP GmbH is the operating company for all European activities in the field of municipal water, waste water and sludge treatment in the SKion GmbH Water Portfolio. ELIQUO offers a comprehensive range of solutions to the municipal water market, from EPC contracting and services to technology implementation for tertiary treatment, aeration and CSO management, and also proprietary technologies for biosolids management, including EloVac®-P.

Details of the demo / pilot

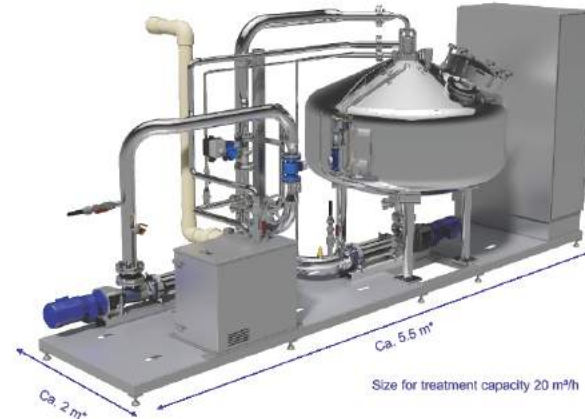
Compact phosphorus precipitation and sequestration system that improves biosolids dewatering while preventing struvite or vivianite scaling and avoiding Green House Gas (GHG) emissions.

Location: Lingen (Ems) - Germany
Municipal WwTP
Design Flow rate: 160 m³/d
Input: Digested sludge (ca. 2.5 - 3% DS)

- Raw sludge is fed to the anaerobic digesters. The digested sludge is treated with LysoTherm® - Eliquo's proprietary Thermal Hydrolysis technology.
- After digestion, biosolids are fed continuously to the EloVac®-P with an PO₄-P concentration of ca. 280 mg/L.
- In the reactor tank, the vacuum degassing increases pH while adding MgCl₂ to enable controlled struvite precipitation.
- Pilot installation was modified to a full installation now running in Lingen, Germany since April 2019.



EloVac®-P



The Experience

In April 2019, Dr. Kopp conducted DS(A) KBKopp Tests, which are accepted by DWA (German Water Association) to predict the achievable solids content in the biosolids.

With EloVac®-P and magnesium dosing directly into the degassing reactor tank (β -factor = $1.5 \pm \sim 3.9 \text{ l/m}^3$), the dry solids (DS) content in the dewatered sludge increased by **5.2%-points**.²

The PO₄-P concentration in the digested biosolids went from 280 mg/l in the baseline sample to 8 mg/l with EloVac®-P, or a **97% reduction**, improving the return load to the head of the works.¹

0.63 kWh_{el}/m³ biosolids can be recovered as green energy through the vacuum degassing process. This also avoids diffuse methane emissions, equivalent to 3 kg CO_{2e}/m³ biosolids. In Lingen, a total of **150 tons of CO_{2e}-emissions** (equivalent to almost 1,200,000 car kilometers) are avoided every year thanks to EloVac®-P.

²Untersuchung des Entwässerungsverhaltens Versuchsbericht / Kennwert TR(A)_{KBKopp}, April 2019

What was the compelling value proposition:

- Simple, easy to install modular system.
- The 5% improvement in the biosolids dewatering, results in approx. 345,000 € in OpEx savings annually with the reduction in the disposal and polymer costs.¹ **Payback period: one year.**
- Phosphate reduction of 95% in the return load to the head works of the plant² by precipitating and sequestering the phosphate in the biosolids.
- Prevent struvite or vivianite scaling downstream of the reactor tank and pipes prior to dewatering.
- Prevention of diffuse methane emissions by extracting residual biogas, which is utilized in the gas engine to operate the unit: **Energy Positive Operation.**

¹Assuming 65€/wet ton disposal cost and 5 €/kg AS polymer.

²The return load to the head works is produced from the centrate of the dewatering downstream the EloVac®-P

What problem did this aim to solve?

EloVac®-P is a very simple retrofit for any and all WwTPs with anaerobic digestion. This technology is particularly beneficial for plants with Thermal Hydrolysis given the higher biogas content in the biosolids post digestion and the higher nutrient release from the Hydrolysis process.

The simultaneous P-precipitation is a feature available for EloVac® (vacuum degassing). EloVac®-P is a perfect fit for WwTPs with elevated levels of Phosphate in the digested sludge.

What this means for the future?

EloVac®-P is the only vacuum degassing system of its kind with phosphate precipitation and sequestration. This compact and skid-mounted technology is a simple retrofit with minimal construction time on site. For a relatively modest investment, plants can now significantly improve dewatering, reduce phosphate concentration in their biosolids and improve their GHG emissions footprint with a simple and small solution.

Eliquo is actively looking for Water Companies in the UK to pilot this technology as a completely skid-mounted system.

Data-Driven Risk Management for Water Distribution Pipes

What problem is being addressed?

Fracta strives to promote a revolution in water industry risk management practices. Moving from reactive, traditional mindset towards a proactive, data-driven approach, Fracta empowers utilities with comprehensive risk analysis with improved accuracy compared to age or burst based models, so that limited resources can be devoted to where it is truly needed the most.

The Fracta Solution.

Fracta is a cloud based Software as a Service offering, providing easy access for utilities to evaluate and manage risks in water distribution mains from Machine Learning (ML). The data-driven process provide subjective view of the system's Likelihood of Failure (LoF) of every segment of pipe in the whole network.

Why Fracta?

1. Fast

6-8 weeks after receiving data to provide condition assessment results.

2. Accurate

5 year time shift studies with multiple utilities show the Fracta model at 80% using balanced accuracy methods.

3. Affordable

Fracta uses existing data from your GIS system without additional requirements for intrusive inspections or desktop assessments, allowing us to provide you with a cost efficient solution.

Benefits of the Fracta Solution

1. Reduce Break Rates and Non-Revenue Water

Machine learning prediction results improves with larger database. The Fracta algorithm has already run more than 95,000 kilometers of pipe in the U.S.. The Fracta model can accurately determine the worst pipes and will get better as we work with utilities around the world.

2. Optimize Capital Investments

Fracta does not only focus on the pipes that's failing, at 80% and above on balanced accuracy scores, Fracta know where good pipes are too, regardless of their age. This enables the utilities to optimize pipe replacement programs instead of conservatively replacing vintage pipes to avoid risks.

3. Cost reductions for more intrusive solutions

Fracta gives utilities a 360 degree view of pipe condition in their whole system. Utilize this information to focus in on high risk area for acoustic detections and where to deploy AMIs and more intrusive technologies.

Example of the Fracta Solution

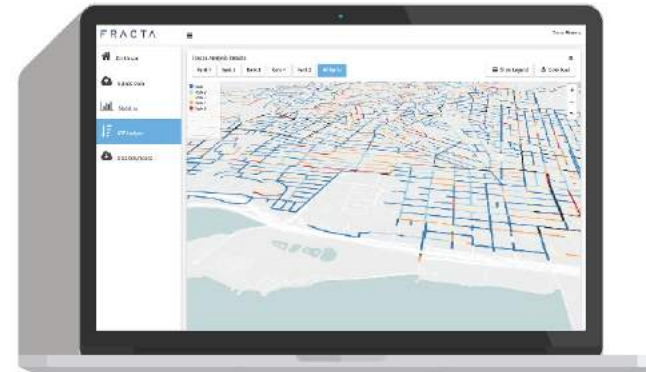


The above graphic illustrates the comparison of the Fracta Model against an age-based model for a medium utility of 847 miles.

Fracta Future Market Outlook

Fracta has currently more than 40 customers across 17 states in the US and is actively growing. We are expanding globally and working with water companies in the UK with our partner Marubeni Corporation of Japan.

We at Fracta believe that Artificial Intelligence and Machine Learning is a concept that will revolutionize the water industry's risk management practice and we strive to work together hand-in-hand with utilities to achieve the best solution possible together.

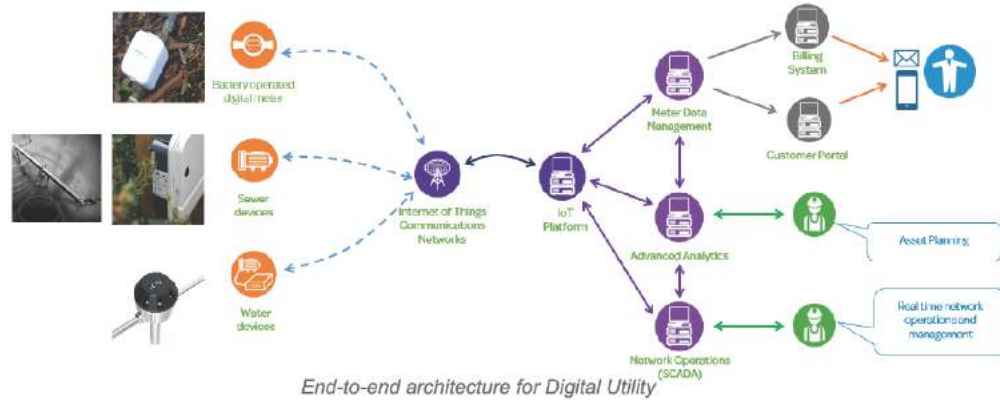


Fracta visualizes the best to the worst pipes in the utilities

Details of the program

Our vision at South East Water: We're helping create a better world for our customers with forward thinking solutions, for all and always, that won't cost the earth.

The digital utility program supports our teams to shift from being reactive to predictive, by providing visibility across our system via a network of different sensors all feeding data into a purpose built IoT platform. This visibility, enhanced by advanced analytics and machine learning will ultimately enable us to meet our goals of reducing bursts, spills and leaks across the network and therefore providing a better experience for customers.



End-to-end architecture for Digital Utility

Some of the field devices currently being deployed include IoT enabled meters, smart valve keys, level and H2S gas monitoring and flow modelled devices for the sewer network as well as remote monitoring and control solutions for the pressure sewer system.

What problem are we solving

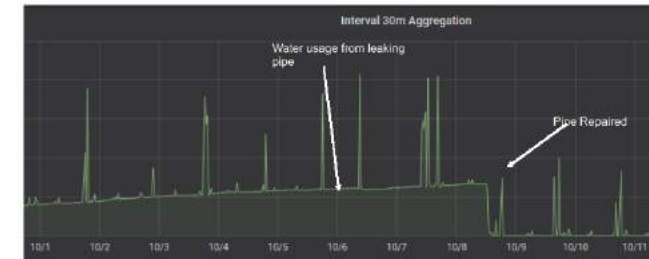
Digital is central to meeting our five customer priorities:

Get the basics right, always	Warn me, inform me	Fair and affordable for all	Make my experience better	Support my community, protect our environment
<ul style="list-style-type: none"> Predict failures Proactively repair Improved service levels 	<ul style="list-style-type: none"> High usage alerts Leak alerts Real-time outage alerts Real-time usage alerts Bill prediction 	<ul style="list-style-type: none"> Asset optimisation and deferral Reduced operating costs and increased productivity 	<ul style="list-style-type: none"> Better understanding of individual customer needs Increased self-serve capability Enhanced digital channels 	<ul style="list-style-type: none"> Minimise water losses Advanced sewer network monitoring Reduced traffic disruption IoT enabled emissions tracking

Case Study displaying customer leak and outcomes using IoT enabled meters:
Continuous flow alert in residential property, investigation found leaking pipe between meter and house.

Up to 280,000 Litres saved in one billing period

Up to \$1,100 Saved by the customer in one billing period



Compelling value proposition

Transform the way we operate by acquiring and analysing near real time data from multiple sources enabling us to become predictive, rather than reactive

The Experience

- Thousands of field devices are already deployed and providing insights to teams across our utility
- Digital meters (or a network of advanced sensors, as we think of them) are spear-heading the development of our water centric IoT platform. Almost 2000 devices are currently deployed and data is supporting leak detection for customers
- Greater visibility of the network is enabling operators to detect blockages before they become spills and understand the status of valves
- We are partnering with other utilities to share learnings, insights and technologies

What this means for the future?

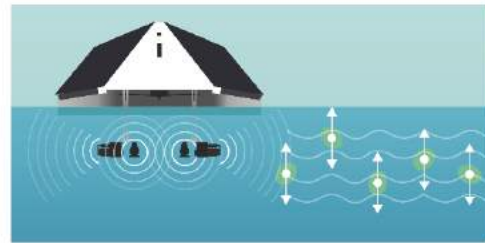
Through our commercialisation arm, Iota, we are uniquely placed to share our learnings and technologies with other water utilities. Based on our collective experience in developing or partnering to create field devices, testing and trialling devices in our purpose built labs and within the network, as well as developing a cloud-based platform to ingest, analyse and visualise the data transmitting from the in-field devices.

Case study American Water

Client: American Water, New Jersey
 Location: New Jersey, United States
 Application: Raw water reservoir
 Reservoir name: Canoe Brook



As an alternative to copper-based algaecides, the use of ultrasonic treatment can be used to control algae. LG Sonic uses specific ultrasonic frequencies to control algae without chemicals. The MPC-Buoy systems reduce algae, through sound pressure, avoiding them from coming up to the water surface. The system uses real-time water quality monitoring to determine the type of algae present in the water and its growth stage. Based on this information, a specific algorithm on an online server automatically changes the ultrasonic program to match the algae present.

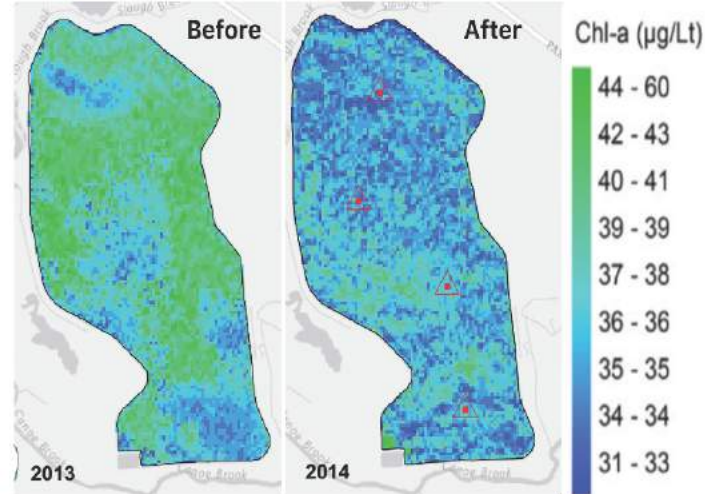


The ultrasound fixes the algae in the water column. Due to a lack of nutrients and sunlight the algae sink to the bottom.

Value proposition

The use of harmful chemicals such as copper and/or chlorine are in this context more and more unwanted, as they are harmful to the environment and often produce unwanted side effects.

MPC-Buoy eliminates up to 90% of the current algae and prevents the growth of new algae without disturbing the ecosystem. By installing the MPC-Buoy, a chemical-free solution for algae control can be provided, that eliminates the use of possibly harmful chemicals in the lake, which are expensive and need to be dosed frequently to provide a continuous solution.



Experience

Extensive testing conducted during 2014 showed that the buoys had a significant impact on the algae, reducing algal counts, raw water turbidity and total organic carbon in the water. This improved water quality, enabled the plant operations staff to reduce coagulant consumption by more than 20 percent and reduced the concentration of undesirable taste –and odor causing compounds in the raw water entering the plant.

Return of Investment

	Chemicals (2013)	MPC-Buoy (2014)
Capital cost	-	\$ 160.000,-
Copper sulfate / cutrine	\$ 60.000,-	-
Alum dose	\$ 1.013,737	\$ 711,940 (saving \$ 23.000)
On-going maintenance of MPC-Buoys		\$15.000,-
Water quality Monitoring	\$ 25.000,-	-
Approximate return of Investment		1.8 years (saving \$ 93,000)

The challenge

The primary objective of this project was to reduce algae concentrations with secondary objectives to reduce the concentration of taste and odor causing compounds in the reservoir water and also to increase the efficiency of the plant by decreasing chemical doses and increasing time between cleaning of the filters.

The current treatment with copper sulfate and cutrine proved only partially effective in Canoe Brook. In addition the risk of creating copper resistant organisms, release of toxins and adverse effects on the environment of copper treatment were factors for American Water to look into alternative algae treatment.

The future

Based on the experience and results of this project, American Water named LG Sonic it's Official Certified Innovation Partner. LG Sonic was the first European company to achieve this. Furthermore, American Water and LG Sonic started new algae control projects in Hawaii, Pennsylvania and Kentucky.

At the moment, LG Sonic MPC-Buoy systems are used in over 22 countries worldwide. Including the United Kingdom, Dubai, Colombia and New Zealand.

MPC-Buoy has been successfully applied in

- Drinking water reservoirs,
- recreational lakes,
- cooling ponds/lakes and
- wastewater lagoons.

The sales of our MPC-Buoy systems grows with over 40% annually.

Nijhuis Industries

Nijhuis Electro Osmosis (NEO)

Energy-efficient solution to minimize sludge disposal



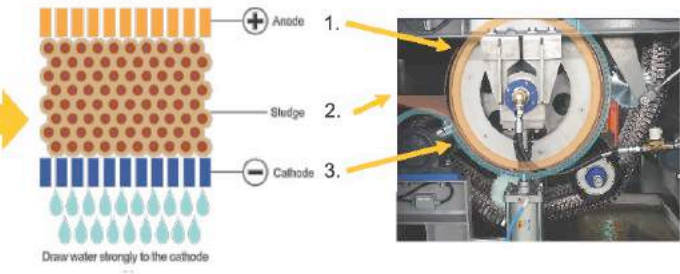
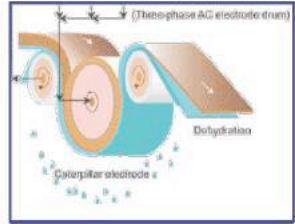
Contact person: Wilbert Menkveld
 wilbert.menkveld@nijhuisindustries.com
 www.nijhuisindustries.com
 Doetinchem | the Netherlands

Principle of the process

By means of electrophoresis, electro-osmosis, and capillary pressure, NEO removes both free water and cell absorbed water from the sludge. NEO consists of an anode drum, a sludge collecting belt, and a cathode caterpillar outside the belt.



Dimension (m) L x W x H	Model
2.7 x 0.6 x 1.5	500S
2.7 x 1.6 x 1.5	1000S
2.8 x 2.6 x 1.6	2000S
2.9 x 3.6 x 1.7	3000S



Compelling Value Proposition

The Nijhuis Electro Osmosis (NEO) is an energy-efficient solution to minimize sludge cost, which amongst others achieves the following benefits:

- Easy to operate, maintain and to integrate after existing centrifuge, belt press or screw press
- Reduced sludge costs (transport, storage, disposal) and pay back time of 2-6 years depending on sludge costs
- Energy efficient solution: 40% less energy consumption per ton sludge compared to thermal dryers
- Reduced CO₂ footprint (reduced amount of cake transport)

Full-scale results

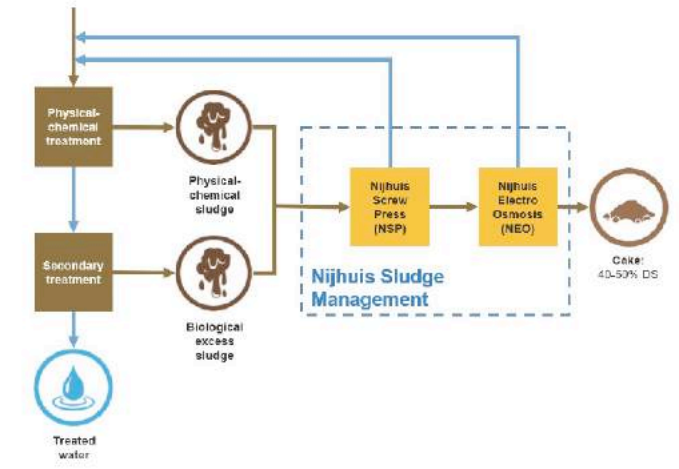


The Drive

Saving sludge disposal costs from site to storage, reduce the amount of sludge disposal and reduce the CO₂ footprint.



Typically, sludge is dewatered up to 15-25%. To further treat the cake, the NEO can reduce the dry cake up to 50% and uses 40% less energy per ton sludge compared to other advanced drying systems.



The Future - Reduce your CO₂ Footprint

In the future, we believe that the Nijhuis Electro Osmosis solution can contribute into reducing the CO₂ footprint by reducing the amount of sludge transports, reduce the energy consumption in comparison to existing thermal dryers and recover a high-quality cake.

Details of the Pilot System

Name of Client: Superior Battery Manufacturing
Location of Plant: Russel Springs, KY
Application Type: Manufacturing Wastewater Treatment
Flow Rate: 2,500 gallons per day
Influent and Effluent spec: Influent is manufacturing wastewater with 50 ppm total Pb; 45 ppm particulate Pb & 5 ppm dissolved Pb. Effluent is water with < 100 ppb total Pb.

This project is a pilot demonstration to prove the feasibility of Capacitive Coagulation to remove Pb using a side stream from the wastewater produced at the manufacturing plant. The data, experience, and feedback from the customer controlled trial will be used to design and implement larger industrial treatment systems for our customers.

Process Description

Capacitive Coagulation (CapCo™) is an electrochemical filter that removes metals from water. It uses carbon-based electrodes and low voltage (< 2 V; < 5 A) to actively attract, immobilize, and filter metals with > 99% selectivity and no sludge production. The CapCo™ device is a hybrid system comprising adsorption (capacitive) and precipitation (coagulation) mechanisms for targeted metal removal. The CapCo™ technology works by using material science and electrochemistry to produce localized pH fluctuations from 2 (anode) to 11 (cathode) in conjunction with (1) electrochemical generation of H₂O₂ at the cathode & (2) electrochemical redox reactions to convert metals into insoluble species that are trapped within the filter. These metals can be recovered or the filter can be disposed in non-hazardous landfill

Compelling Value Proposition

Removing metals from wastewater to meet environmental regulations is an expensive and burdensome process. The dominant incumbent is chemical coagulation & precipitation which yields a toxic sludge by-product.

99% Selective For Heavy Metals
Up To 90% OPEX REDUCTION
0 Sludge By-Product

Heavy Metal Removal Without the Sludge



Demo Unit

150 gpm Skid

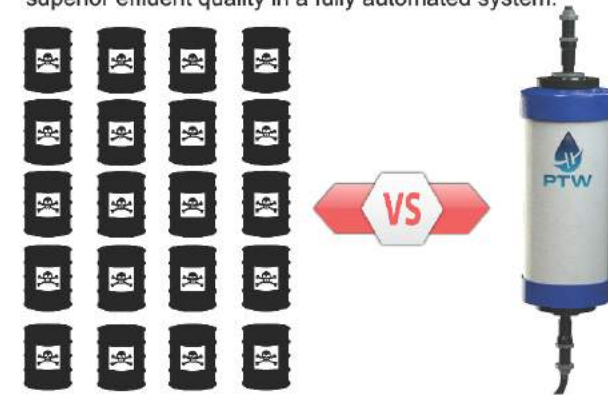
The Experience

The engineering team at Superior Battery Manufacturing tested the CapCo system for lead (Pb) removal with excellent results. The effluent water quality was independently verified by a 3rd party, certified laboratory. Selected results are shown below. CapCo is the most efficient process to remove lead (Pb) and other heavy metals from wastewater streams.

	Chemical Coagulation	CapCo
Volume/Day (gallons)	2,600	2,600
Influent (Pb; ppb)	50,000	50,000
Effluent (Pb; ppb)	150	9
Footprint (ft ²)	8,000	20
Weekly Labor (hrs)	10	0.5
Cost (\$/m ³)	21	5

What Problem Does This Solve

The main problem that CapCo solves is reducing the production of hazardous sludge by-products produced with chemical coagulation and the costs associated with its handling and disposal. Specifically, up to 50 tons of sludge production can be avoided through the use of the CapCo system. This feat is achieved while also reducing labor & maintenance requirements by up to 80% and producing superior effluent quality in a fully automated system.



What This Means For The Future

There are roughly 80 Pb-acid battery manufacturers in USA, and over 400 globally, with similar wastewater qualities and treatment needs. Widespread deployment will result in the avoidance of millions of tons of sludge and their associated hazards such as CO₂ emissions from transportation and disposal. CapCo provides a fundamentally new process to address sustainable industrial wastewater treatment among growing and more stringent regulations.

In addition to toxic Pb contaminants, CapCo will also address a wide breadth of metals observed in industrial wastewaters, such as Cu, Mn, Fe, Al, Cd, Zn, Ni, Hg, Ag, Au and more. This will yield a systemic change for sustainable treatment for a variety of other industries such as microelectronics manufacturing, metal finishing, electroplating, and mining.



PROJECT DETAILS

Industry: Airports - Europe

Applications: Remediation of Per- and Polyfluoroalkyl Substances (PFAS) contaminated groundwater for discharge to surface water

Parameters monitored: pH, Turbidity, TOC, TSS, Iron, Manganese, Alkalinity, 13 different PFAS compounds (PFOS, PFOA, PFBS, PFBA, PFPeA, PFHxS, PFHxA, PFHpA, PFNoA, PFDeA, 8:2 FTS, 4:2 FTS, 6:2 FTS)

Linear Flow Velocity: 4.5 m/hr

Influent: Groundwater with elevated levels of PFAS, Iron and Sulphates

Effluent: Treated water that fulfills limits for discharging PFAS to surface water

CGM was compared to other PFAS removal technologies, namely GAC and IX Resin. The sampled groundwater was pre-treated using a storage aeration tank followed by a sand filter to remove elevated levels of Iron and TSS. The pre-treated water was then passed through three packed bed columns, operated in parallel, containing CGM, GAC and IX Resin.



COMPELLING VALUE PROPOSITION

- Can be tailored dependent on compounds/chemical groups of interest
- Exhibits a high affinity towards PFAS, leading to fast adsorption kinetics and increased removal performance.
- An easy and flexible solution that can be applied in packed bed vessels; possible to retrofit into existing infrastructure
- Shorter Empty Bed Contact Times and longer operating lifecycles leading to less maintenance and lower OPEX
- Is regenerable using a simple and safe aqueous regeneration procedure onsite, therefore can be used multiple times.
- A highly cost-effective solution with total lifecycle costs lower compared to other adsorbents

CGM VS OTHER TREATMENT TECHNOLOGIES

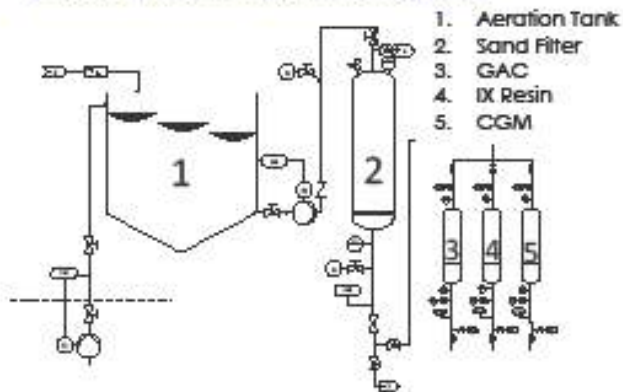
	CGM	IX Resin	GAC	RO
Removal Efficiency	★★★★★	★★★★	★★★	★★★
Footprint	★★★★★	★★★★	★★★	★★★
CapEx	★★★★★	★★★★	★★★	★★★
OpEx	★★★★★	★★★★	★★★	★★★

PFAS AND THE AIRPORT INDUSTRY

PFAS are commonly found in Aqueous Film Forming Foams (AFFF) as advanced fire-retardant technologies in use from the 1970s. AFFF are critical to health and safety operations of many high-risk environments including airports, military bases and oil & gas sites. However, their use causes contamination due to its infiltration into soil and groundwater. Airports are now facing a major challenge to control the discharge and contamination of PFAS impacted soil and water.

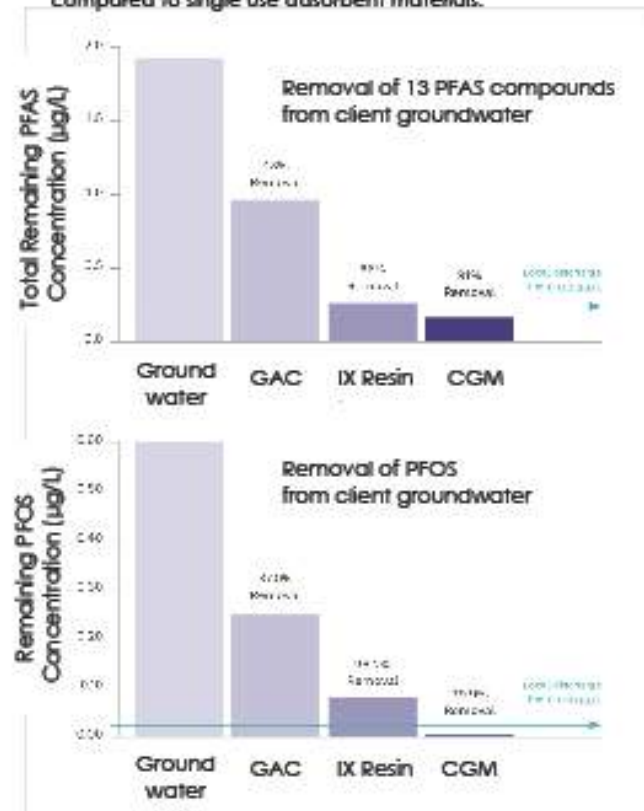
Puraffinity is working with one of the busiest airports in Europe to deliver a high performance, sustainable and cost effective PFAS treatment solution. The airport faces a new regulatory landscape, requiring treatment of contaminated groundwater to meet new PFAS limits for discharge into the environment. The discharge regulations are: 0.23 µg/L (230 ng/L) for the sum of 13 different PFAS compounds and 0.02 µg/L (20 ng/L) for PFOS.

GROUNDWATER TREATMENT SET-UP



RESULTS

CGM removed total PFAS at a higher rate than GAC or IX resin, leading to discharge of PFAS well within PFAS and PFOS regulatory limits. CGM removed 91% of total PFAS and 99% of PFOS from the client's impacted water. Regeneration tests indicated that CGM offered a 200% increase in lifetime compared to single use adsorbent materials.



A lifecycle assessment and return on investment was calculated based on operational data generated in this trial. When considering the ability to regenerate CGM onsite, deployment of CGM would equate to a 33 – 70% reduction in OPEX compared to the airport's current solution. Such a solution represents a highly attractive return on investment period of 1 – 2 years to the client.

Details of the field trials

Field trials carried out at Cumwhinton WTW in Cumbria with the support of the United Utilities Innovations Lab.

UV Disinfection

3rd Party Validation Testing to USEPA UVDGM protocol conducted by Jim Bolton of Bolton Photosciences Inc. over a 2-month period which concluded in July 2018

First validated LED UV System worldwide

Application Type: Drinking Water Disinfection

Flow rate up to 250m³/h

UVT ≥90%

4-Log Cryptosporidium deactivation and 40mJ/cm² RED (Reduction Equivalent Dose) general disinfection

Further validation of the BIO-310 Reactor is expected later this year due to developments in LED technology.

AOP

First full scale pilot of LED UV AOP solution worldwide from September 2017 through to February 2018

Purpose: to demonstrate the ability of the technology to degrade geosmin – which causes taste and odour issues - from a typical water source.

Sodium Hypochlorite has a peak absorbance at 292nm.

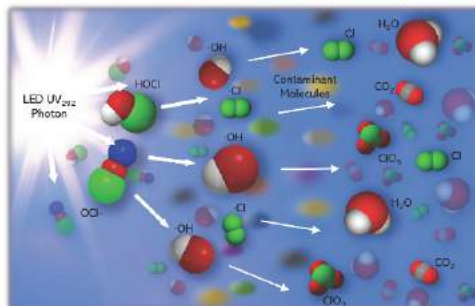
LED wavelength output is adaptable hence maximising the efficiency of hydroxyl radical formation.

The study has highlighted the importance of optimising

the chlorine concentration and pH levels to deliver the most efficient UV Dose.

The rapid development of UV LEDs has seen the system output

increase by 40x since the trial, indicating that flows of up to 200m³/h are now achievable.



BIO-310 UV Reactor installed at Cumwhinton WTW

What is the compelling value proposition?

- Decreasing annual OPEX costs and whole life cost savings in excess of 50% compared to traditional mercury lamp reactors.
- Design Resilience allowing retrofit with future generations of LED's
- Operational Resilience and Increasing Asset Capacity
- Sustainable Solution with no mercury protecting the environment and against legislative changes
- No quartz lamps or sleeves in the reactor flow so no threat of breakages passing downstream
- Instant ON/OFF and Unlimited turndown to optimise dose
- No fouling or solarisation caused by heat reducing maintenance time.
- Overdrive capacity to deal with contamination and maintenance events
- Proven, validated performance



What problem did this aim to solve?

UV Systems are used across the water industry for both Disinfection and as part of an Advanced Oxidation Process (AOP)

However traditional mercury lamp UV systems are regarded as inefficient, power hungry and in some situations a H&S risk.

Typhon has developed the world's first validated LED UV System suitable for continuous municipal/industrial scale applications.

Typhon's innovative use of LED's in an integrated array delivers photons into the UV reactor in the most efficient way possible

The design also enhances integration and control and builds in resilience and flexibility

A BIO-310 LED UV system installed today will deliver continuous annual OPEX savings and system performance increases as LED technology develops.

What this means for the future?

There is wide agreement that LED technology will revolutionise the UV Disinfection industry. The only question is how quickly...

Typhon have developed the first LED UV system which can compete with traditional mercury lamp technology UV-C LED's are developing at a rapid pace (Haitz Law: 20X Power Increase and 10X Price decrease every 10 years).

A BIO-310 system purchased today will double in capacity in the next 3 to 4 years.

Increases in reactor capacity open up opportunities for how Utilities manage their UV assets

As UV-C LED's increase in output, water reuse, storm water and wastewater applications are becoming a realistic prospect.

Transitioning to LED UV now starts to remove the mercury issue and builds resilience and sustainability into the water treatment plant infrastructure.

Details of the Pilot / Plant

Client: **Public Utility Company**

Location of plant: **Northern Italy**

Application Type: **biological process acceleration in an urban WWT plant**

Secondary stage: Activated sludge biological reactor

Influent specification:

	Plant Capacity	Watermax Boost
Capacity (population equivalent)	7.000 p.e.	11.000 p.e.
Treated volume	58 m ³ /h	> 97 m ³ /h
BOD load reach	<420 kg/day	> 1.100 kg/day
Ammonia (NH ₃) concentration	Beyond Limit	90% reduction

Nanobubbles [20-2000 nm range] have fundamentally different properties than other bubbles: their size offers 10M more surface area to volume ratio than normal bubbles; and can **remain in the fluid for many weeks or month**; vastly improving the gas transferability.

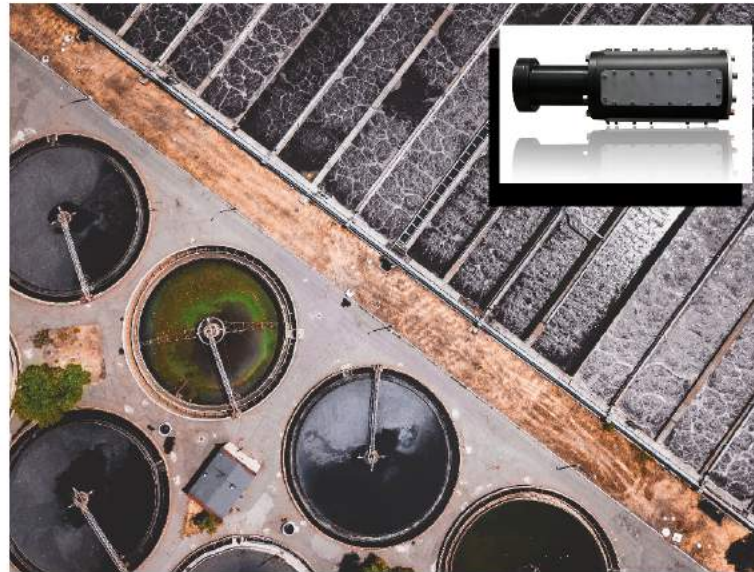
Compelling Value Proposition

Currently more than 10% of municipal WWT plants across the EU (>40 m population equivalent) are not in line with EU directives according to European Environmental Agency.

Rebuilding and / or refitting these [often old] plants is expensive for the communities, and generally require long approval and installation times.

Watermax boost offers:

- a **simple, fast to install solution** at the **fraction of the cost** of a refitting or expansion of a WWTP that results in an increased peak load capacity by 40%.
- **4x more efficient oxygenation**, that can be used through smart controls, and support reduction of the average energy spend.



The Experience

Installation:

Less than 1 day. Installation can be emerged in the water basin as well as on land

Pilot flow rates:

Phase 1 [boost functionality]: 50m³/h recirculating flow

Results:

Original aerator: 0.5 kg of O₂/kW
Phase 1 results: 2.0 kg of O₂/kW (4x boost)
Increased oxygen input to 60 kg/day
>90% NH₃ concentration reduction during peak hours
>50% additional BOD removed (calculated)

What Problem Do We Solve

The WWTP, built in the 80s, can no longer deal with peaks demand (BOD load in excess) and EU regulations require lower ammonia concentrations.

Problems are linked to **insufficient oxygenation** in the biological tank.

WATERMAX is demonstrating with the pilot that it is possible to **provide more oxygen** to the aerobic process, with a **low cost and easy to install solution**.

The **AIR-50** an **AIR-200** nanobubble generators boost aeration, speed up the elimination of dissolved organics and ammonia thereby increase the plant's capacity.

What this means for the Future

Now there is an **easy to install, low CAPEX solution to boost capacity** enabling to reduce time and investments needed to upgrade older plants capacity to meet EU norms.

The nanobubble solution promises furthermore to **increase energy efficiency up to 50%** by leveraging data and smart algorithms- a critical OPEX component Watermax is piloting this year [phase 2] in waste water treatment.

WATERMAX is looking to roll-out its boost solutions across many applications:

- **environmental water treatment** like seawater contamination in ports, ground water contamination in gasoil stations
- energy savings in **heavy-duty waste water** treatment in the paper petrochemical industry.
- **high efficiency waste water** treatment in constraint places such as autonomous toilets in trains and boats
- **process improvements for gas/liquid processes** in chemical and mining industry

Fully Automated Rapid Microbiology

Microbiological contamination as Process Parameter



VWMS GmbH
Vienna Water Monitoring Solutions
Favoritenstraße 4-6/ 13 - 1040 Vienna
AUSTRIA
T.: +43 2284 20 188-0
www.v-w-m.at

Customers and Pilots

MEKOROT (IL); RAND WATER (SA); Seoul Metropolitan Water Institute (KR) ; MSD Cincinnati (USA); DSD (HK), NIWA (NZ), DHI (DK), EVN (A); Polytechnique Montreal (CAN), KIT (D); Trojan UV (CAN) ; and many more.

Track Record

03 2014 – First prototypes deployed in the field
01 2016 – First industrial devices presented at IWS Abu Dhabi
02 2017 – Version CMI 01
10 2018 – Version CMI 02

In field operation since more than 5 years, deployed in different applications around the globe since 2016. The measurement devices did prove their reliability and robustness even under extreme conditions of environment but as well in measuring very difficult sample matrices.

Measurement Approach

The ColiMinder is directly measuring the metabolic- (specific enzymatic-) activity of target bacteria present in the sample. A direct measurement of the energetic turnover of living bacteria. The ColiMinder uses a spectrofluorometric measurement to measure enzymatic activity. Depending on the reagents* used, the activity of different target organisms can be measured.

The Value proposition

A fully automated measurement system performing rapid microbiological on-line measurements, delivering result in 15 min. -independent of the level of contamination - enabling process monitoring and control for all water related applications.

- fully automated measurement, cleaning, calibration
- receive real-time results on microbial contamination
- monitor process performance
- control disinfection > and avoid overdosing disinfectant
- safe direct process costs
- increase food & beverage safety
- know when to CIP – reducing downtime
- assure batch quality

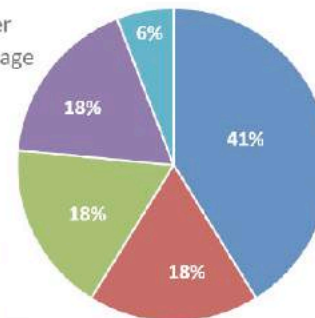


The Application Fields

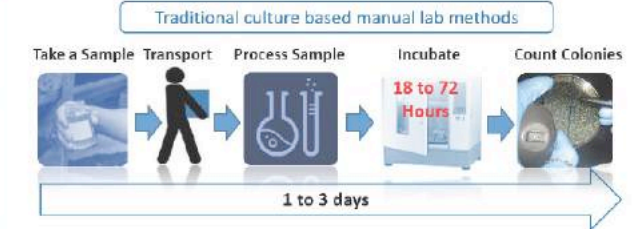
Since 2016 our customers use our devices in various applications.

- Surface-/Bathing-/Raw-Water
- Drinking Water/Food&Beverage
- Waste Water
- Membrane Integrity
- Cooling Lubricants

- *Reagents available for
- E. COLI**
Specific indicator of faecal pollution
 - ENTEROCOCCI**
Specific indicator of faecal pollution
 - TOTAL ACTIVITY**
Bulk parameter of total microbiological activity



Problem the ColiMinder Solves



Microbiological contamination, most important water quality parameter, is still evaluated manually by a 1-3 days lab procedure which is not suitable for automation, online monitoring and process control.



Providing microbiological contamination as online parameter for process-automation/ control, monitoring and early warning.

What this means for the future?

A first step into a new era: microbiological contamination measurement is available in real-time, enabling a dramatic increase in efficiency & safety of water treatment process for circular economy.

Direct process feedback on microbiological contamination allows to develop new, and for the first time controlled processes addressing microbiological contamination based on real-time measurement data.