Ultra-Oxygen

Optimise your water quality with tiny bubbles

"The Ultimate Sustainable Global Dissolved Oxygen Solution for Water"

www.ultra-oxygen.com

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OXYGEN TRANSFER EFFICIENCY (OTE)

of UO2

MICRO and ULTRAFINE BUBBLE (MB/UFB)

EQUIPMENT TESTED

For

Independent Equipment Distributors & Partners

02 March 2023 – rev 1

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1 INTRODUCTION

1.1 Project Support and Water Quality Solutions.

1.1.1 **Building a Better Tomorrow, Today**: At SOLDEVCO/Ultra-Oxygen, we are dedicated partners in sustainability, driving change through innovative technology and sustainable solutions for a greener future. United in collaboration, we optimise success for our clients with a solution-driven approach, always prioritizing quality without compromise.

1.1.2 At SOLDEVCO/Ultra-Oxygen, we are passionate about creating a greener, more sustainable future for all. Our focus is on industries that align with our expertise and innovative technology, including project support, agriculture, aquaculture, aquaponics, water quality, and wastewater treatment.

1.1.3 We believe in the power of collaboration and strive to build long-term partnerships with our clients. We shift the traditional business model of selling to one of collaboration, where the goal is to create mutually beneficial relationships that drive positive change and promote sustainability. Join us as we work together towards a brighter future.

"WE ARE IN THIS TOGETHER".

1.1.4 The present article aims to present the test methodology, conditions, and results of tests conducted using Ultra-Oxygen's patented equipment. The tests aim to evaluate the efficiency of Ultra-Oxygen's aeration equipment and provide a clear and concise explanation of its performance.

1.1.5 This article will present the methodology and conditions used in the tests, as well as the results obtained. The goal is to provide a comprehensive and accessible overview of Ultra-Oxygen's micro and ultrafine bubble technology and its advantages as a cost-effective, sustainable, and energy-efficient solution for aeration equipment.

1.1.6 The article is intended to serve as a useful reference for individuals seeking information on the benefits and performance of Ultra-Oxygen's technology and to provide guidance on the key considerations when evaluating investments in micro and ultrafine bubble generation equipment.

1.2 Our Core Values

1.2.1 **Empowering People, Building Partnerships, Achieving Purpose with Professionalism and Integrity** - At Soldevco (Pty) Ltd, we believe in the power of people, partnerships, and purpose. We are passionate about our work and are driven by the desire to deliver professionalism and integrity in everything we do. We believe that by treating our employees and customers with dignity and respect, we can create a safe and inclusive workplace that celebrates diversity.

1.2.2 **Empowering progress through accountability and innovation** - Empowerment and accountability are at the core of our values. We are not afraid to take on challenges and turn them into opportunities. Our leadership style is proactive and client-focused, and we are always looking for ways to improve and innovate. We understand that the satisfaction of our customers is the foundation of our success and longevity, and we are dedicated to managing your business with the same level of care and responsibility as if it were our own.

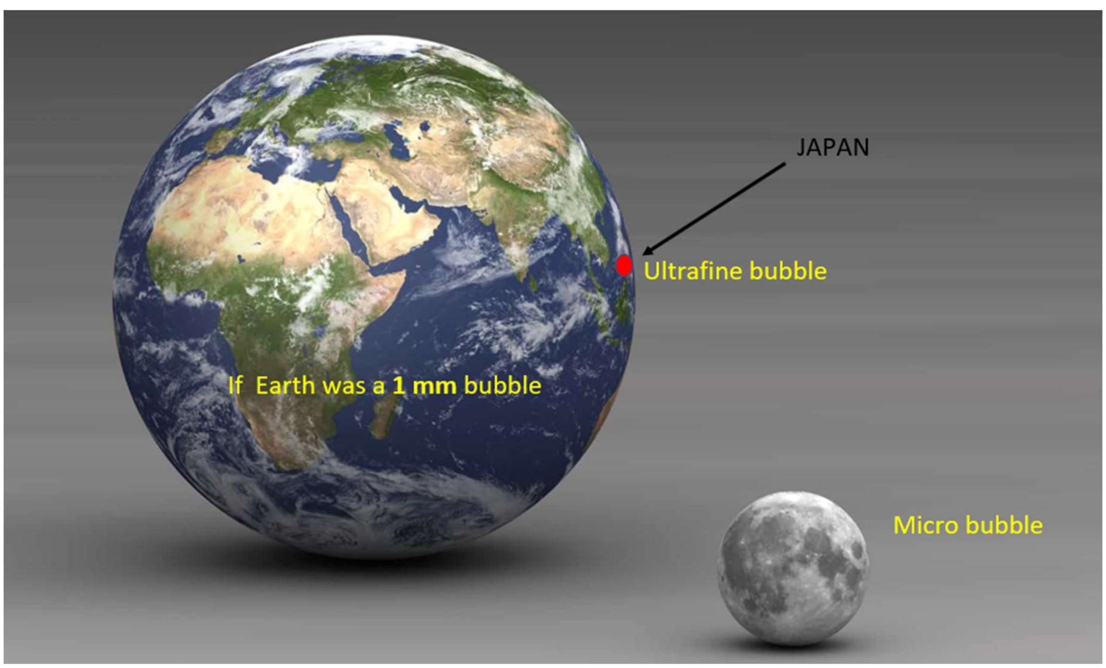
1.3 What makes Ultra-Oxygen bubbles so special?

1.3.1 Micro and Ultrafine bubbles generated with the patented equipment of Ultra-Oxygen, are not your ordinary bubbles. These tiny, charged bubbles possess remarkable properties that set them apart from their larger counterparts. Ultrafine bubbles are so small that they measure under 50 microns and can even shrink naturally down to 300 nanometres. These bubbles are incredibly stable, neutrally buoyant, and can remain suspended in water for months.

1.3.2 Ultrafine bubbles are not just any bubbles; they have a charged surface that can perform electrochemistry and oxidative reactions. With the right mixture of iron and oxygen molecules, these bubbles can do oxidation reactions, making them ideal for a variety of applications.

1.3.3 These tiny bubbles also have the ability to reduce surface tension and pH of water, creating amazing effects in the water. This unique class of bubbles has even gained a new classification under ISO/TC 281 – Fine bubble technology.

1.3.4 Ultrafine bubbles are truly a superior aeration technology that can efficiently aerate the entire water column. With all these fascinating benefits, it is no wonder that ultrafine bubbles are a game-changer in many industries.



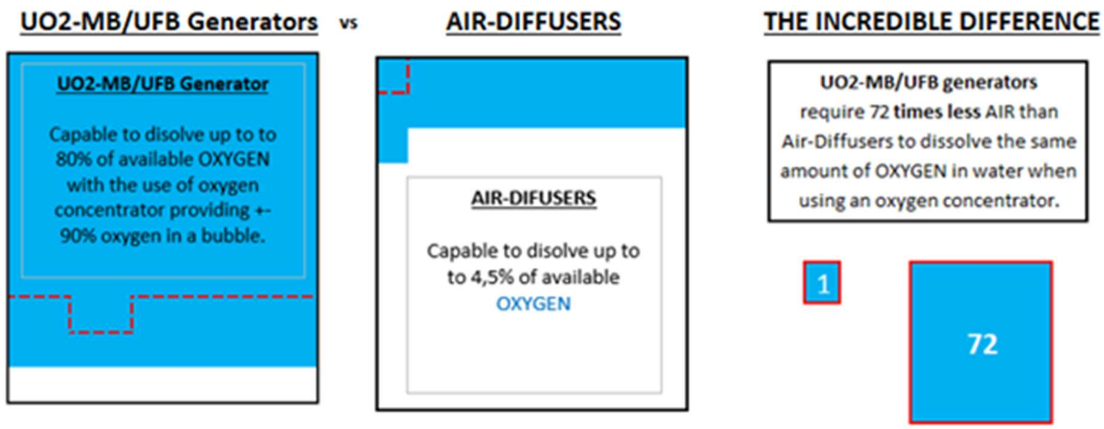
1.3.5 Visit https://ultra-oxygen.com/ to learn more about the world of MICRO and ULTRA-FINE BUBBLES.

1.4 Problems or issues shared with us by engineers and farmers, solved.

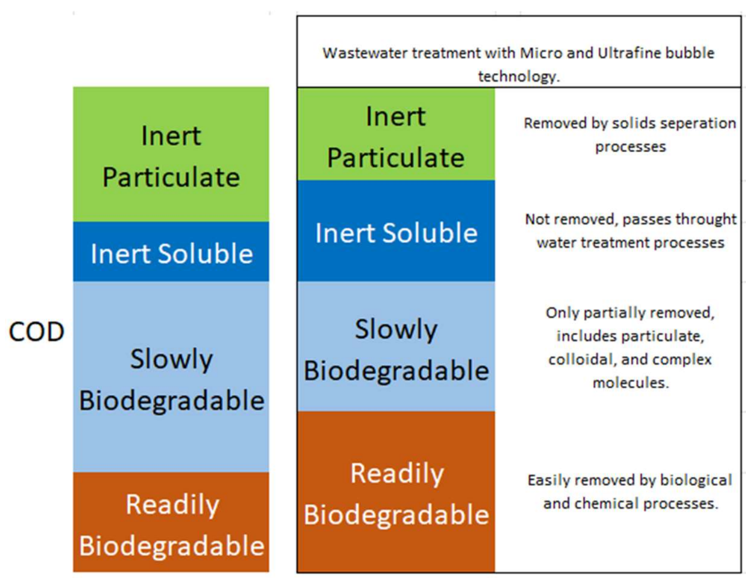
1.4.1 As a key component in water treatment solutions, **dissolved oxygen (DO)** holds a central role, often referred to as the **"Queen Bee".** It is critical for engineers to possess a thorough understanding of the required oxygen levels and the methods for supplying them efficiently.

1.4.2 It is of utmost importance for engineers to comprehend the recent advancements in utilizing pure oxygen (PO) and ozone effectively in combination with micro and ultrafine bubble generators. Implementing these technologies into designs can greatly enhance their performance.

1.4.3 Our tests have demonstrated that PO can be utilized with remarkable efficiency, as compared to traditional air blowers widely used in wastewater treatment plants. In fact, our results have shown that using PO with UO2-MB/UFB generators can achieve the same results while consuming 72 times less air.

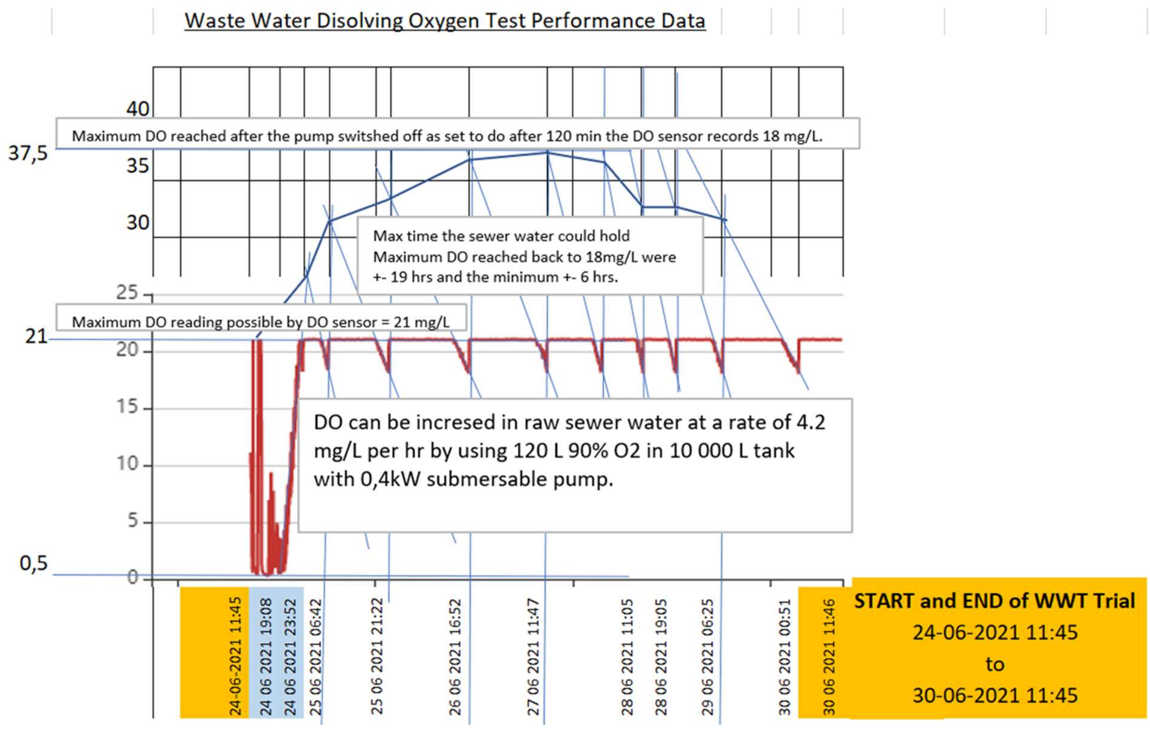


1.4.4 Our technology used, demonstrated that it improves the treatability and efficiency of wastewater treatment, mainly due to the ability to remove surfactants, enabling Lower cost to treat (less CAPEX and OPEX), Wastewater treatment intensification, Increased treatment capacity, Smaller process units & ancillary equipment, Improved energy efficiency, Improved BOD / COD / N removal efficiencies, Less chemical usage, Best-in-class overall process (removal and energy) efficiency.



1.4.5 An engineer at the local municipality requested a trial to test the time it will take to raise the dissolved oxygen levels in raw sewer water and to see what will happen with the water quality BEFORE it is treated.

1.4.6 We observed that we could again increase the DO very effectively from 0.52mg/L up to 26mg/L within 4 hours with only one UO2-1N using 2.5 L/min pure oxygen (PO) in a 10 000L tank, after stabilising the load within 12 hours, despite the high COD load of 7 895 mg/L received. The aeration time needed after 1 day was 30 min every +- 15 hrs to keep the DO levels between 18 and 37.5 mg/L. Below some of the key results recorded.



Wemmershoek WWTW	Raw Sample 1	Sample 2	Sample 4
Laboratory ID	21/2810	21/2811	21/2999
Date:	24 Jun 21	25 Jun 21	30 Jun 21
pH			6,94
Time			
^{0}C			16,5
EC mS/m			128,4
TDS Measured			821,76
TSS			15
COD Unfiltered	7895	413	328
NH_3-N	80,04	83,60	85,30
TKN	215	98	75
Total Phosphate as P	7,57	8,15	8,21
Alkalinty	387	347	351

1.4.7 **Aquaponics** technology integrates biology, which **connects aquaculture with** the principle of recirculation, together with the production of **hydroponic plants or vegetables**. It is a more environmentally friendly technology. This system will decrease nitrogen concentration contained in water in fish-care containers because of the presence of biofilter in the form of plants. In the fish-raising container, water containing nitrogen (ammonia, nitrite, and nitrate) is channelled to the plants and then used as nutrients. Water containing nitrogen in fish-rearing tanks will be oxidised through a biological process called nitrification. Nitrification is an inorganic nitrogen removal process that can occur optimally when sufficient dissolved oxygen needs are met in fish rearing.

1.4.8 Maintaining oxygen levels in the nutrient solution of aquaponic systems, particularly those using the deep flow technique (DFT), is essential for the root uptake of nutrients and cellular respiration. However, more frequent, extreme, and longer heatwaves because of climate change threaten aquaponic and outdoor hydroponic growers because oxygen levels in the nutrient solution decrease as temperature increases. Low dissolved oxygen (DO) levels can adversely affect growth rates and yield, making it difficult for growers to meet customers' demands. Current strategies for increasing DO with ambient air into the water beds (nutrient tanks) using air pumps with air stones and surface contact with atmospheric oxygen are not able to raise the DO levels quickly enough when dissolved oxygen losses are experienced.

1.4.9 Low DO levels negatively impact the water quality and rhizophagy cycle of the plants, limiting yields, sustainability, and profitability in general.

1.4.10 **Where the farmer wants to see financial benefits and operational improvements.**

Yield is affected by multiple variables that affect plant growth. One of the most critical variables is water quality with healthy dissolved oxygen levels. Ultra-Oxygen MB/UFB technology must consistently provide the needed oxygen levels in the water.

To reduce the loss in yields previously caused by low oxygen levels in the water.

To improve farming and cultivation methods by utilising the higher DO levels available to increase quality and yields across various crops.

Provide higher DO levels to reduce the reliance on chemical treatments and to enhance the needed biology used in aquaponics.

Provide higher DO levels to reduce the risk of crop losses, improve root health, suppress pathogens, increase nutrient uptake efficiency, and better enable crops to withstand environmental stresses with UO2 oxygen-rich water.

To restore lost oxygen in water, avoid anaerobic water's adverse effects.

To improve the ability to reuse water, the "Blue Gold" of the planet.

Explore options to help farmers farm more sustainably, with fewer risks, while saving OPEX costs in the long run.

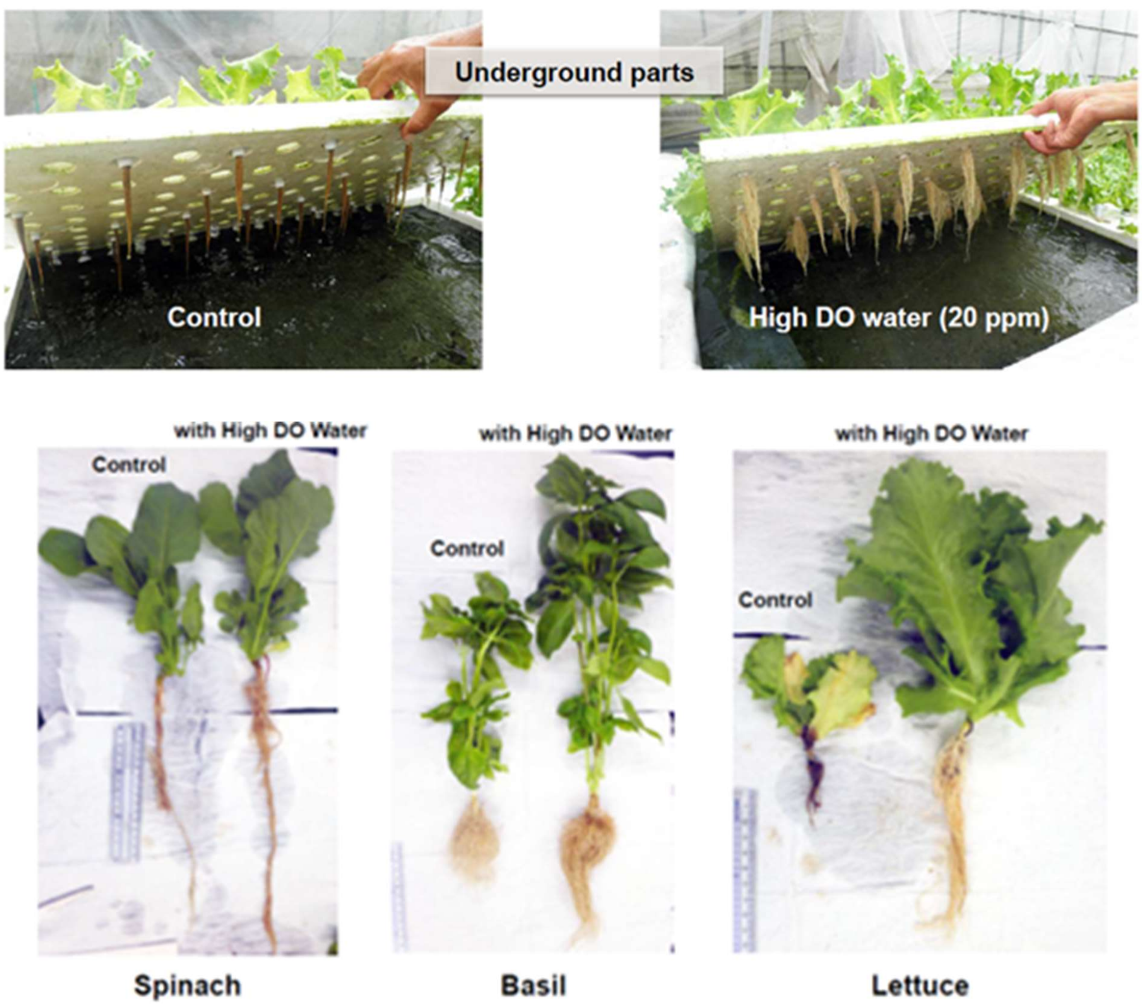
1.4.11 The results obtained indicated that when ambient air was used, UO2-MB/UFB equipment improve the farmer's best possible DO levels before the start of the trial, by at least 37%. The maximum DO level reached on this specific site was 7.98mg/L.

1.4.12 Second Phase Test - +- 90% Oxygen was generated by a medical-grade oxygen concentrator in the second phase of the test to determine how quickly the DO levels could be raised higher than achieved with ambient air. For precautionary measurements, it was decided to switch off the UO2 MB/UFB equipment when readings reach 9,5mg/L to avoid a reading higher than 10mg/L in the fish tanks. The DO levels were expected to rise due to the distance and speed the bubbles move through the system.

1.4.13 The results indicated that an oxygen concentrator could improve DO levels by at least 83,56%. The maximum DO level reached in the three waterbeds was 11,5 mg/L. (UO2-VIPER-MB/UFB generator used 1 367 L of water to raise DO in +- 13 000 L of water within 20 min)

1.4.14 A 100% oxygen level improvement was easily achieved with the UO2-MB/UFB technology, and a 60% drop in energy costs was possible while enjoying the system's 100% increase in oxygen levels.

1.4.15 The following results were obtained <u>in a different study</u> with UO2-MB/UFB generators within three weeks, using water saturated with oxygen up to +-30mg/L.



1.4.16 The major benefits users recorded, studies verified, and results obtained from using MB/UFB aeration equipment can be summarized as follows:

- Ability to replace lost oxygen in water bodies very fast and efficient.
- Ability to use other gasses such as ozone more efficiently in water treatment processes.
- Ability to supersaturate water with oxygen up +- 450% - 38mg/L
- Eliminate up to 70% to 90% of algae.
- 50% chlorophyll reduction
- 80% to 100% Manganese, Iron, Hydrogen Sulphide, and Copper Sulphate Reduction
- Prevent the occurrence of toxic blue green algae.
- Increase agriculture productivity.
- Control fouling in sand filters and clarifiers.
- Prevent biofouling growth.
- Safe for fish, plants, and other aquatic life
- Reduce and prevents taste and odour problems.
- Improve water quality, reduce pH, TSS, BOD and chemical dosage.
- Remove surfactants,
- Enabling Lower cost to treat wastewater (less CAPEX and OPEX),
- Increased treatment capacity of WWTP.
- Smaller process units & ancillary equipment required to improve water quality.
- Improved energy efficiency to treat water.
- Improved BOD / COD / N removal efficiencies
- Less chemical usage
- Best-in-class overall process (removal and energy) efficiency.
- Prevent clogging of filters.
- Improve coagulation and flocculation processes.
- Reduce the risk of spreading legionella.
- Improve habitat for fish and wildlife. and increase Aesthetic Appearances.
- Lower bacterial counts.
- Reduce chemical expenses.
- Yield and Quality of crops.
- Health of all species that live in water.
- Healthier environment.
- Humans' well-being.

1.4.17 Also now available - UO2-Drylet supplementary award-winning Biocatalyst for enhanced bioremediation assures viability of microbes, protects microbes from phages and predators by housing them in a special patented silica substrate, ensures retention of microbes in the system, is very effective in liquid and solid layers.

2 WHERE TO START TO IMPLEMENT MB/UFB AERATION?

2.1.1 The first step in designing an aeration system is to determine the oxygen demand. Although process model simulations aid in determining oxygen demand and aeration requirements, it is important to understand the factors that influence oxygen demand and how oxygen demand is calculated.

2.1.2 Establishing the correct flow and load criteria is imperative to the success of the aeration system design. **Design guidelines recommend accounting for the 24-hour demand of the average day of the peak month when calculating the maximum aeration requirements.**

2.2 The four musketeers.

2.2.1 **OXYGEN** (The Boss) - You must know how much Oxygen (not air) is needed to treat the water.

2.2.2 **VOLUME** – You must know how much volume of water must be treated.

2.2.3 **TIME** – You must know how much time you have to dissolve the OXYGEN in the VOLUME of water received.

2.2.4 **QUALITY** – You must know the quality requirements your discharge water must adhere to before discharging it.

2.2.5 The catch is:

1. To know how to use the worst water quality results obtained from reputable laboratories or water sensors, and how to determine from these results the maximum OXYGEN required to be dissolved in the VOLUME of water received in TIME to be able to discharge the QUALITY of water that will benefit the ecosystem without using chemicals most cost-effectively and sustainably.

2. Not to forget to ask for a “Future Focused Value Engineering” report that includes all upstream and downstream CAPEX and OPEX values of at least two aeration options, to be able to choose the best aeration equipment for the job. Ignoring upstream and downstream requirements are just foolish.

3. To know how to challenge aeration performance results and understand them in context.

4. Know how to compare apples with apples – to be able to do this correctly with aeration equipment, you must obtain the answers to <u>ALL</u> the following questions.
    a. The list of equipment needed to dissolve oxygen in a specific VOLUME of water to a specific dissolved OXYGEN level. (For example, ask to oxygenate 10 000L to a DO level of 25 mg/L)
    b. The TIME it will take to dissolve the oxygen to the requested DO level.
    c. Cost of all the equipment combined to be able to perform the aeration task. (CAPEX)
    d. Cost to maintain the equipment over a period of two years at least. (OPEX)
    e. Most importantly – What impact will the process have on the environment? (For example, ask what chemicals are used and its “Material Safety Data Sheet” to be provided.)

IMPORTANT: Ask for performance reports and test results of equipment.

3 DISSOLVED OXYGEN'S IMPORTANCE

3.1 What's dissolved oxygen (DO)?

3.1.1 Dissolved oxygen (DO) is the existence of free, non-compound oxygen present in water or other liquids, gaseous, molecular oxygen in the form of O2, not bonded to any other element, naturally originating from the atmosphere or as a by-product of photosynthesis.

3.1.2 The bonded oxygen molecule in water (H2O) is in a compound and does not count toward dissolved oxygen levels. One can imagine that free oxygen molecules dissolve in water much the way salt or sugar does when it is stirred.

3.1.3 Once dissolved in water, it is available for use by fish, invertebrates, aquatic plants, plants, animals, good bacteria, and all other living organisms. **DO** play a significant role in many chemical processes in the aquatic environment and **is considered the most important measure of water quality** as it is a direct indicator of an aquatic resource's ability to support aquatic life.

3.1.4 Microbes such as bacteria and fungi require dissolved oxygen (DO) to decompose organic material in water. Microbial decomposition is a crucial contributor to nutrient recycling and if there is an excess of pollution and decaying organic material (from dying algae and other organisms), the oxygen levels will get used up quicker.

3.1.5 Anaerobic conditions then occur when the uptake or disappearance of oxygen is greater than its production by photosynthesis, diffusion, or aeration. Many anaerobic bacteria produce enzymes that destroy tissue or sometimes release potent toxins.

3.1.6 The only way to restore nature in this state is to add oxygen back to the water, and here lies the challenge.

3.1.7 Normal aeration bubbles only contain 21% oxygen, rise too fast and require a high energy source to transfer enough oxygen to restore the water in an aerobic condition.

3.1.8 Ultra-Oxygen Micro and Ultrafine bubble-generating technology solved this problem by creating bubbles that rise very slowly and can stay in water for months if not used. This allows the use of oxygen generators that produce up to 93% oxygen efficiently for the first time in the history of aeration.

3.1.9 Dissolved oxygen is usually reported in milligrams per liter (mg/L), as a percent (%) of air saturation, or in parts per million (ppm). 1 mg/L is equal to 1 ppm.

3.1.10 Dissolved oxygen is an essential factor for the activity of microbial biocatalysts used in enhanced bioremediation, as it is a key component for aerobic respiration, the primary metabolic pathway for many microorganisms.

3.1.11 During aerobic respiration, microorganisms use oxygen to break down organic compounds into energy, carbon dioxide, and water. This process releases energy that can be used to fuel microbial growth and metabolism. In the context of bioremediation, microorganisms use this process to break down contaminants in contaminated environments such as soil or water.

3.1.12 The presence of dissolved oxygen in the environment promotes the growth and activity of aerobic microorganisms that can degrade pollutants, such as hydrocarbons and other organic compounds, more efficiently than anaerobic microorganisms. By providing sufficient dissolved oxygen, the bioremediation process can be accelerated, allowing for faster and more complete removal of contaminants from the environment.

3.1.13 Therefore, the availability of dissolved oxygen is critical for the activity of aerobic microorganisms and the success of enhanced bioremediation techniques that rely on these microorganisms as biocatalysts. In situations where dissolved oxygen is limited, alternative remediation approaches may need to be considered, such as anaerobic bioremediation or the use of other non-biological remediation methods.

3.1.14 Ultra-Oxygen micro and ultrafine bubble (MB/UFB) generators transfer more oxygen into the water compared to conventional aeration techniques, creating a more oxygen-rich environment that can enhance the activity of aerobic microorganisms involved in bioremediation. This increased oxygen supply help to improve the metabolic activity of microorganisms, promoting their growth and increasing their biocatalytic efficiency.

3.1.15 Using MB/UFB technology also helps to reduce the toxicity of pollutants by promoting the biodegradation of contaminants into less harmful compounds. This can be particularly important for the bioremediation of organic pollutants, such as petroleum hydrocarbons, where UFBs can enhance the activity of aerobic and anaerobic microorganisms involved in the degradation process.

3.1.16 Overall, the use of MB/UFBs in microbial biocatalysts for enhanced bioremediation can help to improve the efficiency and effectiveness of the bioremediation process, making it a promising technology for the treatment of contaminated water and soil.

4 UO2 MB/UFB PERFORMANCE TESTS

4.1 Test Methodology used to prove the performance of UO2 equipment.

4.1.1 The performance of the UO2-MB/UFB-1N generator was evaluated through two distinct tests.

4.1.2 The **first test** was carried out in accordance with the standards set forth by the American Society of Civil Engineers in their "Measurement of Oxygen Transfer in Clean Water" (**ASCE/EWRI 2-06**) guidelines, with some additional calculations performed. The process involved measuring the concentration of dissolved oxygen over time and determining the mass transfer coefficient through non-linear regression. To achieve a low concentration of dissolved oxygen, the test water was deoxygenated through the use of nitrogen gas or sodium sulphite, depending on the type of aeration system and the feasibility of a particular method. The power consumption of the aeration devices was monitored using power monitoring equipment that was suitable for systems equipped with variable speed drives. Tests were conducted at various duty points to determine the efficiency of the system across its entire operational range.

4.1.3 The **second test** was carried out by a third-party specialist in fluid particle measurement, using the **ParticleTrack G600**. Particle size and count play a crucial role in multi-phase processes such as crystallization, emulsification, and flocculation. By measuring particle size and count in real-time, engineers were provided with a deeper understanding of how the bubbles generated by our equipment lift and flocculate particles, which is one of the key factors that contribute to improving wastewater treatment processes.

4.1.4 The test was performed using normal, clean drinking water from a tap as the control. Particles were measured as they passed the lens without mixing, then with mixing to determine the size and amount of particles present in the water. The water was oxygenated using 90% pure oxygen and micro and ultrafine bubbles to a concentration of 20mg/L, and the particles were measured again as they passed the lens without mixing, followed by another measurement with mixing to determine if any flocculation had occurred. This process provided insight into the size of the particles that were lifted by the ultrafine bubbles.

4.1.5 Based on the results of these tests, Ultra-Oxygen developed its own calculator to evaluate the performance of its equipment, and to be able to perform tests in the field in any environment to determine site-specific designs based on real-world data. This method should be incorporated into the current wastewater treatment design formulas used in practice by engineers or clients for a simpler, more straightforward evaluation of compliance.

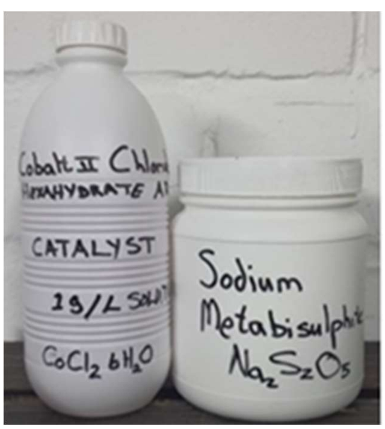
4.2 The testing environment for tests 1 and 2.

4.2.1 **Test 1:**

The methodology for evaluating the performance of Ultra-Oxygen's micro and ultrafine bubble aeration equipment was based on the ASCE (American Society of Civil Engineers) standard "Measurement of Oxygen Transfer in Clean Water" (ASCE/EWRI 2-06). Clean tap water was used as the test medium in all experiments.




4.2.2 The deoxygenation of the test water was performed using Cobalt as a catalyst and Sodium Metabisulphite. To monitor the tests, various equipment was used, including a calibrated dissolved oxygen (DO) meter, a pH meter, a total dissolved solids meter, a green laser, a stopwatch, and pen and paper.

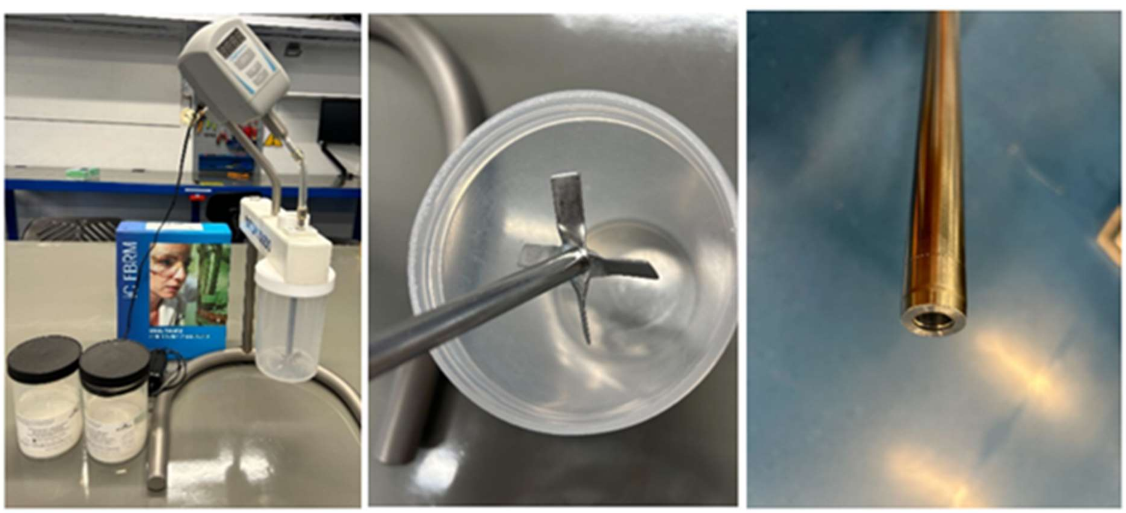



4.2.3 The setup of the experiment involved capturing the dissolved oxygen concentration in the reactor, which was achieved by turning on the Ultra-Oxygen equipment after the concentration reached 0.01mg/L. The DO readings were taken every 15 seconds while the equipment was supplying oxygen to the system. The experiment was repeated to ensure accuracy and repeatability. A data collection table was developed to record the DO readings, and the data was captured in a calculator to determine the oxygen transfer efficiency of the aeration equipment.

4.2.4 In the study, tests were conducted using both ambient air and a +-90% oxygen generator to demonstrate the efficiency of dissolving oxygen in water. The results of these tests are presented in the article, providing insights into the performance of Ultra-Oxygen's micro and ultrafine bubble technology.

4.2.5 **Test 2:**

This test was done by a third party that specialises in measuring particles in fluids. In situ measurement of the ParticleTrack G600, at full process concentration, provided an immediate measurement of the particles and droplets as they actually exist within the current process or in their natural environment.



4.3 The results.

4.3.1 First Test

4.3.2 In wastewater treatment, one of the most vital processes is the aeration stage, where aerobic bacteria digest the organic material as a function of the available dissolved oxygen in the entering raw materials.

4.3.3 What needs to be determined is if the rate of transfer is sufficient to bring down the operating costs of the plant by allowing a larger oxygen transfer rate (OTR) per unit of power consumed.

4.3.4 The oxygen transfer model used to fit the data can be seen in equation 2 where:

C = DO concentration (mg/L)

$C^*\infty$ = determination point value of the steady-state DO saturation concentration as the time approaches infinity (mg/L)

C0 = DO concentration at time zero (mg/L)

Kla= determination point value of the apparent volumetric mass transfer coefficient (1/t) defined so that (equation 1):

$$K_L a = \frac{rate\ of\ mass\ transfer\ per\ unit\ volume}{(C_\infty^* - C_0)} \qquad 1$$

$$C = C_\infty^* - (C_\infty^* - C_0)e^{(-K_L at)} \qquad 2$$

4.3.5 The above model was fit to the data to determine the KLa of the UO2-MB/UFB generator setup. It was also used to provide a predictable repeatable model for the system, thus allowing for a mathematical representation of the performance of the setup to compare to other diffuser-blower setups.

4.3.6 Experimental conditions.

	Test 1 ($90\% O_2$)	**Test 2** ($21\% O_2$)	**Units**
Water temperature	17.7	17.8	°C
TDS (Total Dissolved Solids)	1360	1470	ppm
Initial DO (Dissolved Oxygen)	0.01	0.01	mg/L
Reactor Depth	0.4	0.4	m
Reactor Width and Length	1	1	m
Reactor Volume	400	400	L

Oxygen volume and weight differences when using Ambient air vs 90% oxygen concentrator in AIR.

4.3.7 ***Test 1:***

Air with 90% Oxygen in a bubble:

Oxygen density – 1,43 g/L ;

Air density – 1,23 g/L;

1kg Air – 816 L;

O2 in 1 m3 90% oxygen Air

– 735 L – 1,05 kg

4.3.8 ***Test 2:***

Air with 21% Oxygen (Ambient Air) in a bubble:

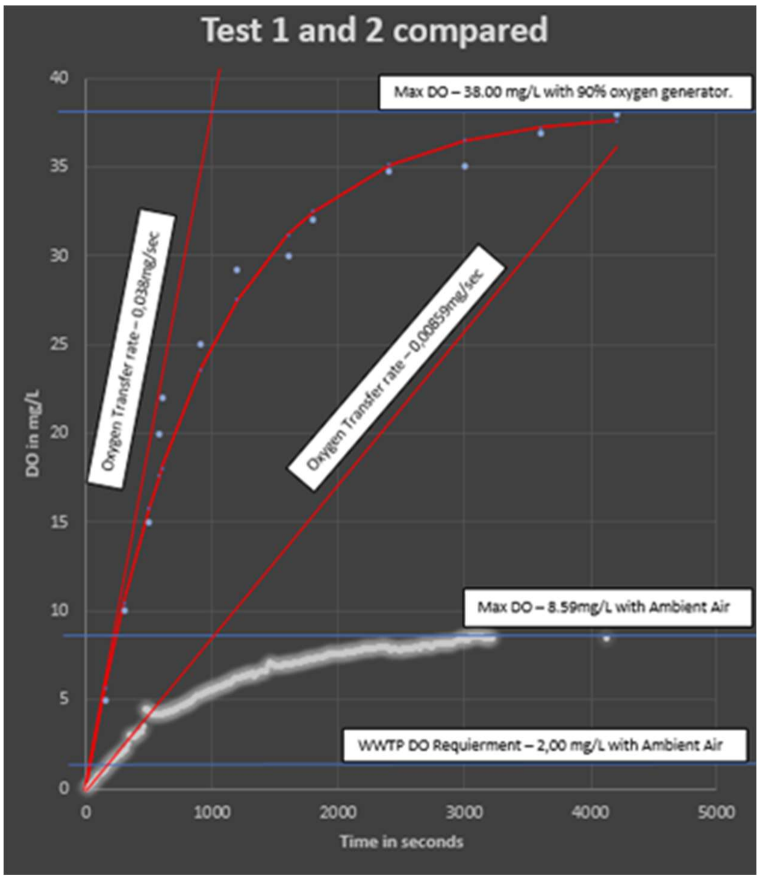
Oxygen density – 1,43 g/L;

Air density – 1,23 g/L;

1kg Air – 816L;

O2 in 1 m3 Ambient Air

– 171,4 L – 0,245 kg

4.3.9 

4.3.10 The UO2-SS-1N was used in both tests and mounted on a 0.4 kW submersible pump. The water flow and air suction through the UO2-MB/UFB generator were measured and were 0,767 L/sec and 0,042 L/sec respectively. (Gas, Water ratio _ G:W _ 1 : 18.4) The water temperature was 18 degrees, PH 2.72, TDS 1360 ppm, and the volume of water treated, was 400 litres.

4.3.11 The **Oxygen Transfer Efficiency** are applicable to the volume of water treated, and the volume of water used by the UO2-MB/UFB generator, carrying the dissolved oxygen to the reservoir.

4.3.12 It is crucial to review both values when comparing other MB/UFB generators with each other. (also known as “nanobubble generators”)

4.3.13 Below is the logic that should be followed when determining the **OTE reservoir** and **OTE MB/UFB Generator** values.

4.3.14 **OTE reservoir**

OTE reservoir (%) = Actual O2 dissolved (A) / O2 feed available to be dissolved (B)

A (kg) = Reservoir Volume x DO reading

B (kg) = Volume of gas feed x % O2 x O2 density

Observation:

From all the available oxygen fed, **51% to 56% O2 could be transferred** into the water. However, from 22mg/L the ability to transfer the oxygen decreased downwards to 13.79% when the DO flattened out on 38mg/L.

4.3.15 **OTR and OTE MB/UFB Generator**

OTE UO2-1N (%) = Actual O2 dissolved at a specific time / Volume of water used by the UO2-MB/UFB generator

Observation:

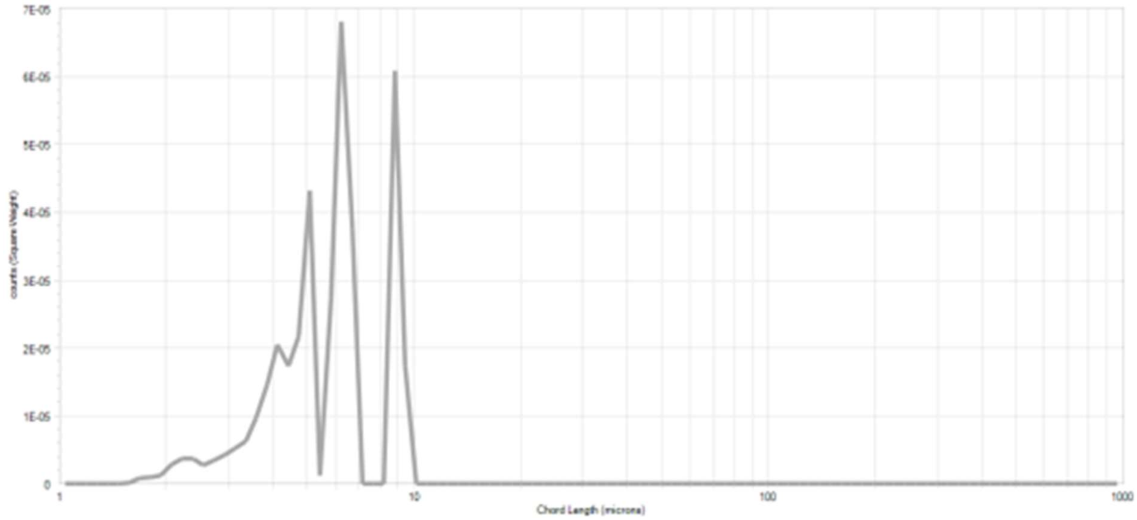
To be able to achieve the **OTE reservoir** values, the UO2-MB/UFB generator must be able to "doze" oxygen successfully at a specific rate (**OTR**). From the results, it was clear that the oxygen was "dozed" at a rate between 17,39 mg/L to a maximum value of 19,13 mg/L. These values expressed in % saturation are approximately 195,41% to 215% OTE. However, from 22mg/L, the ability to "doze" the oxygen decreased downwards to 4,72 mg/L when the DO flattened out on 38mg/L. Between 0 and 20mg/L the OTR = 2,609 kg O2/m3 water

4.3.16 Second Test

4.3.17 The test was done with ParticleTrack G600. Particle size and count directly impact performance in multiphase processes including crystallization, emulsification, and flocculation. By measuring particle size and count in real-time, we believe that we gave engineers some understanding of how well the bubbles generated by our equipment lift and flocculate particles. This specific characteristic of MB/UFB technology is one of the main contributing factors to significantly improving WWT processes.

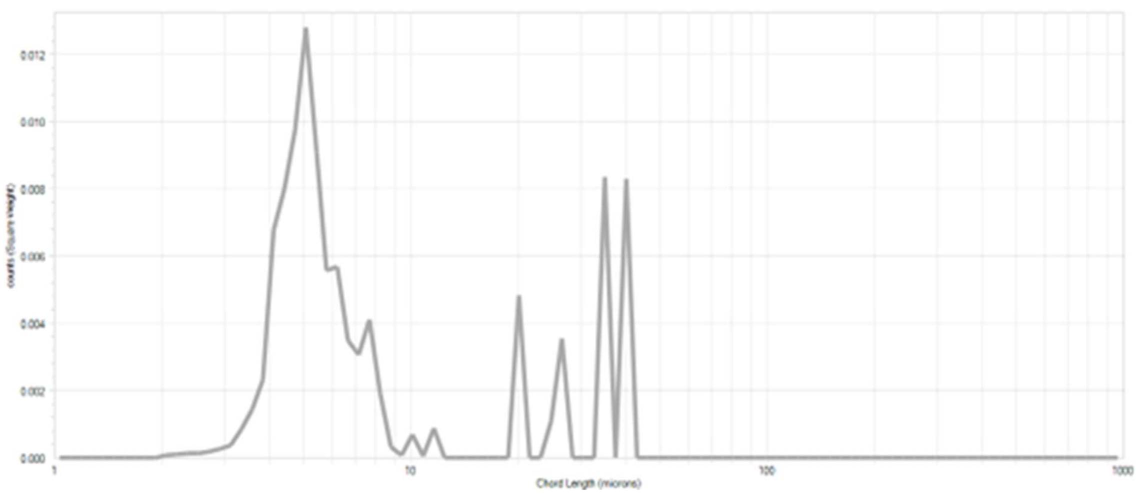
4.3.18 Normal clean drinking water quality from a tap was used in the test.

4.3.19 **Fig 1** – Measurement of the particles that moved past the lens without any mixing.



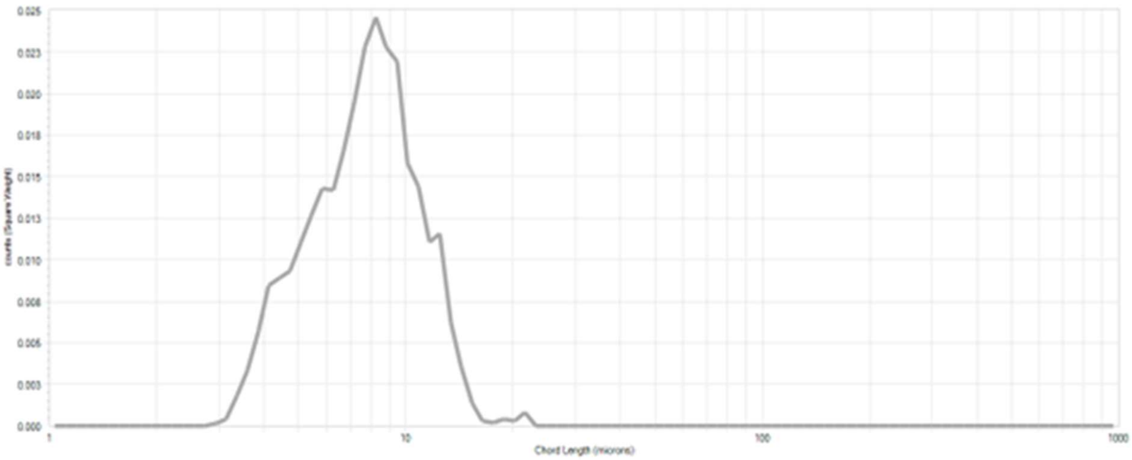
4.3.20 The result indicated that when the water is still in the cup virtually zero particles were picked up by the sensor. Maximum reading of 0.000068 counts per square weight (cpsw) between 1 and 10 microns was recorded.

4.3.21 **Fig 2** – Mixer in the cup switched on to use the turbulence to determine any particles lying on the bottom of the cup or stuck to the walls of the cup.



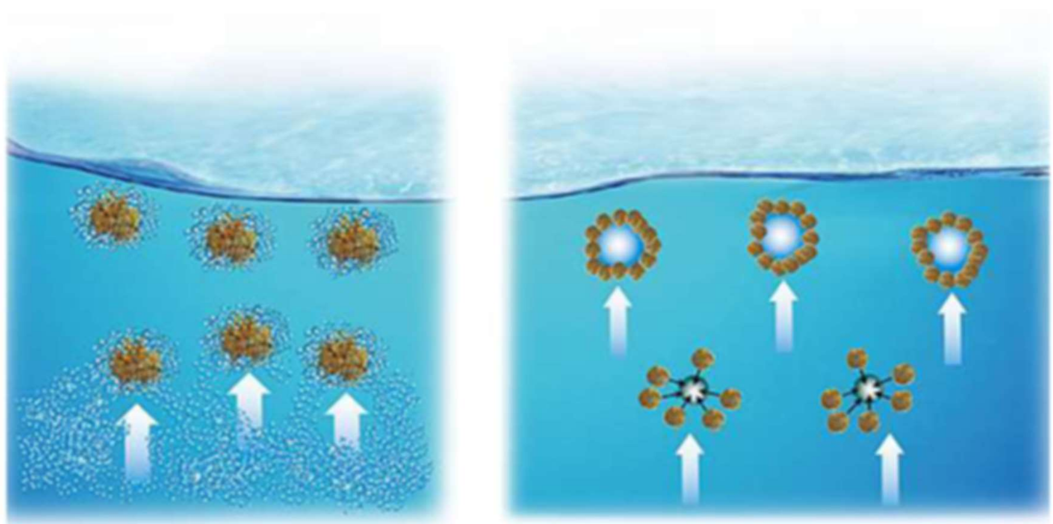
4.3.22 The result indicated that some particles are only visible when moved in the cup. A more realistic value of the number of particles was obtained with this method. Maximum reading of 0.0128 counts per square weight (cpsw) between 2 and 45 microns was recorded.

4.3.23 **Fig 3** – The water is impregnated with Ultrafine bubbles (UFB) using the UO2-MB/UFB-1N, feeding it with pure oxygen of 90%, to a dissolved oxygen (DO) level of 20mg/L. The sample was poured into the cup and a measurement was taken to measure the particles that moved past the lens <u>without any mixing.</u>



4.3.24 The result indicated that the particles were lifted by the UFB rising and transporting the particles past the lens. The size of the bubbles was not measured but it can be assumed that the largest bubble size was in the region of 20 microns. The graph also showed a favourable grouping of the particles. Maximum reading of 0.0248 counts per square weight (cpsw) between 2 and 45 microns was recorded.

4.3.25 Ultrafine bubbles are more effective in floating particles compared to larger bubbles due to several reasons:



4.3.26

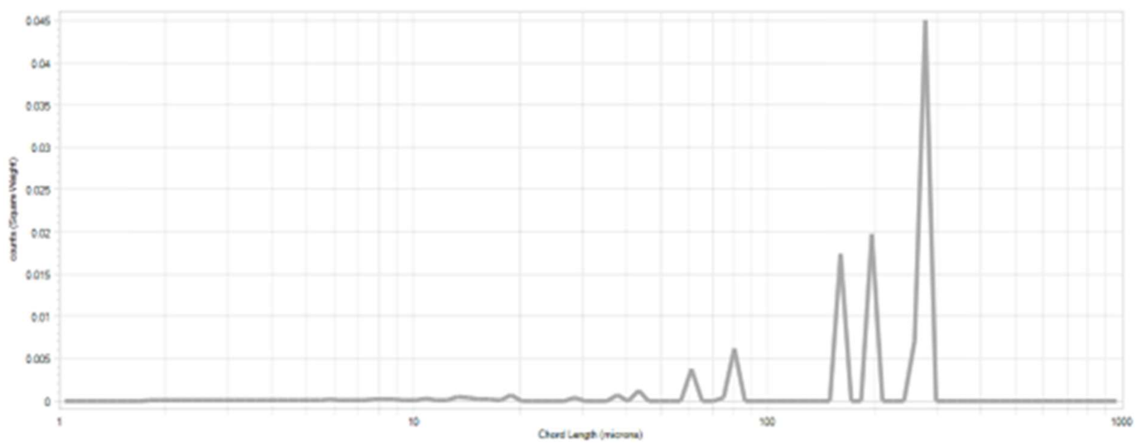
4.3.27 Surface-to-Volume Ratio: Ultrafine bubbles have a higher surface-to-volume ratio compared to larger bubbles, which means they have more surface area relative to their volume. This increased surface area makes ultrafine bubbles more effective in capturing and floating particles compared to larger bubbles.

4.3.28 Penetration Ability: Ultrafine bubbles are small in size, which allows them to penetrate into small crevices and indentations of particles and contaminants, capturing them more effectively. Larger bubbles, on the other hand, are not able to penetrate into these small areas and may simply float over the particles, leaving them behind.

4.3.29 Buoyancy: Due to their low density, bubbles of any size have a natural tendency to rise to the surface. Ultrafine bubbles, being small and lightweight, rise to the surface, although much slower than larger bubbles, giving them the ability to capture particles more effectively and float the particles to the surface.

4.3.30 Collision Efficiency: The smaller size of ultrafine bubbles also makes them more effective in colliding with particles and contaminants, which increases the chance of capturing and floating the particles to the surface. Larger bubbles have a lower collision efficiency and may simply pass by the particles without capturing them.

4.3.31 **Fig 4** – The sample used in Fig 3 were stirred with the mixer after 2 min to determine if any form of flocculation will take place.



4.3.32 The result indicated that the particles were bigger and that some flocculation did take place. Maximum reading of 0.045 counts per square weight (cpsw) between 10 and 300 microns was recorded.

4.4 Test conclusion

4.4.1 **Test 1 - UO2-1N-MB/UFB OTE and OTR tests**

4.4.2 From the results, we ascertained that for wastewater treatment where a constant 2-3 mg/L is required the UO2-1N-MB/UFB generator outperformed normal disk and strip diffusers by far.

4.4.3 Technical data obtained from various commonly used air diffuser manufacturers revealed that the actual oxygen transfer efficiency ranged between 1% - 2% whereas the UO2-MB/UFB generator can dissolve gas at a rate of 50 to 215% and can use at least 72 times less air to do the same job. efficiently.

4.4.4 General observation: *It must be said that I did not find any aeration diffuser supplier proving the actual maximum dissolved oxygen levels obtained when treating a specific volume of water with a specific volume of air constantly. You should ask for this information to truly understand the information provided on the SOTE graphs.*

4.4.5 UO2-1N-MB/UFB generator, when using an oxygen concentrator that provided 90% oxygen in the air bubbles could dissolve the oxygen in the 400 L of water at a rate of 0.038 mg/sec, a phenomenal 442 % increase in efficiency when compared to using ambient air. A 427% saturation was achieved with a max dozing rate of +- 18 mg/L.

4.4.6 When using ambient air, the oxygen was dissolved in the 400 L reservoir at a rate of 0.00859 mg/sec. An 88% saturation was achieved.

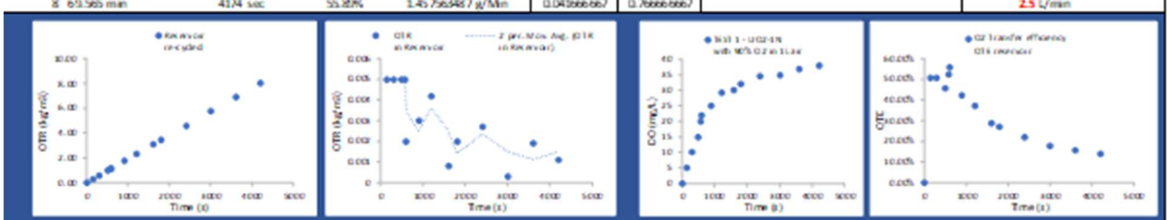
4.4.7 All data site-specific data obtained are captured in a specially developed calculator to monitor equipment performance relative to the actual site conditions.

4.4.8 The following picture is the results of Test 1 completed.

Data Collection Table for Aeration Efficiency Test

Date: 24 Jun 22 — TEST 1 — Time: 10:40 am

The time it will take to re-cycle the reservoir.			Oxygen density:	1.429 g/L	Vessel Volume per Min		Solution:	Reservoir volume:	Energy data	
1	8.6957 min	522 sec	Air Density:	1.225 g/L	(the volume of air per volume of reactor per time)		Water	400 L	Power (kW)	0.4
2	17.391 min	1043 sec	1kg Air:	816.327 L			Total Disolved Solids(TDS):	Equipement depth:	Time (hr)	1.17
3	26.087 min	1565 sec	Volume O_2 in 1 m^3 Air	734.694 L	0.00625 vvm		1360 ppm	0.4 m	ENERGY (KwH)	0.466666667
4	34.783 min	2087 sec	O_2	1049.878 g	G:W ratio		Electrical Conductivity:	Water temp:	46 L/min	
5	43.478 min	2609 sec	O_2	1.050 kg	1	18.4	247 mV	18 °C	Gas Supply	
6	52.174 min	3130 sec	Oxygenation achieved		Gas Flow Used	Water Flow Used	Potential Hydrogen:	Atmosphere temp:	Oxygen	90%
7	60.87 min	3652 sec	73%	2.607925 g/Min	(L/sec)	(L/sec)	2.72 pH	20 °C	Gas Flow:	
8	69.565 min	4174 sec	55.80%	1.457563487 g/Min	0.041666667	0.766666667			2.5 L/min	



$OTR_{7.05}$ 0.4174 kg/hr — k_La 0.001073162 — TEST 1 - UO2-1N with 90% O_2 in 1L air — AE=OTR/P 1.043478261 kg O2 dissolved / kWhr

Actual O2 added to reservoir (mg)	(Kg)	OTR in Reservoir (kgO2/m3)	OTR per volume water treated by MB/UFB generator (kgO2/m3)	Duration of test (t) minutes	O_2 FEED Max O_2 available to be dissolved. B = (kg)	(l)	Reservoir re-cycled (#times)	Volume of Gas used ((L/sec) x sec) (L)	Volume of Water used ((L/sec) x sec) (L)	Duration of test (t) (sec)	DO reading recorded (mg/L)	Oxygen dissolved in the reservoir (Reservoir Volume x DO reading) (mg)	A = (Kg)	O2 Transfer efficiency $OTE_{reservoir}$ A/B	UO2-1N-MB/UFB generator Oxygen DOZING RATE 8.9mg/L = 100% saturation (mg/l)
				0.00	0.000		0.00	0.00	0.00	0	0.01	4	0.000004	0.00%	
1996	0.002	0.00499	26.03	2.50	0.004	5.625	0.29	6.25	115.00	150	5	2000	0.002	50.81%	17.39
2000	0.002	0.005	26.09	5.00	0.008	11.250	0.58	12.50	230.00	300	10	4000	0.004	50.81%	17.39
2000	0.002	0.005	26.09	8.33	0.013	18.750	0.96	20.83	383.33	500	15	6000	0.006	45.73%	15.65
2000	0.002	0.005	26.09	9.67	0.015	21.750	1.11	24.17	444.67	580	20	8000	0.008	52.56%	17.99
800	0.0008	0.002	10.43	10.00	0.016	22.500	1.15	25.00	460.00	600	22	8800	0.0088	55.80%	19.13
1200	0.0012	0.003	15.65	15.00	0.024	33.750	1.73	37.50	690.00	900	25	10000	0.01	42.34%	14.49
1680	0.0017	0.0042	21.91	20.00	0.031	45.000	2.30	50.00	920.00	1200	29.2	11680	0.01168	37.09%	12.70
320	0.0003	0.0008	04.17	26.67	0.042	60.000	3.07	66.67	1226.67	1600	30	12000	0.012	28.58%	9.78
800	0.0008	0.002	10.43	30.00	0.047	67.500	3.45	75.00	1380.00	1800	32	12800	0.0128	27.10%	9.28
1080	0.0011	0.0027	14.09	40.00	0.063	90.000	4.60	100.00	1840.00	2400	34.7	13880	0.01388	22.04%	7.54
120	0.0001	0.0003	01.57	50.00	0.079	112.500	5.75	125.00	2300.00	3000	35	14000	0.014	17.78%	6.09
760	0.0008	0.0019	09.91	60.00	0.094	135.000	6.90	150.00	2760.00	3600	36.9	14760	0.01476	15.62%	5.35
440	0.0004	0.0011	05.74	70.00	0.110	157.500	8.05	175.00	3220.00	4200	38	15200	0.0152	13.79%	4.72
15 196	Max.	0.005	26.09							Max readings:	38			55.80%	19.13

0.4 m3 treated @ 0.000766667 m3/min (Water Flow of UO2-1N-MB/UFB generator)

Time it took to reach this value? 4200

A clearer picture is available on request.

Table 1 - UO2-MB/UFB GENERATORS vs DIFFUSERS with AIR BLOWERS

PERFORMANCE FACTORS FOR CONSIDERATION	UO2-MB/UFB Generators	AIR blowers with Diffusers
Bubble sizes in terms of ISO standards.	SMALL Micro and Ultrafine bubbles	LARGE Fine course and Course bubbles
Maximum dissolve oxygen(DO) level using AIR (21% oxygen)	8.59 mg/L (96.52% saturation)	7.1 mg/L (79.78 % saturation)
Maximum dissolve oxygen(DO) level using AIR (90% oxygen)	38 mg/L (427% saturation)	Not feasible/unable to compete
Require additional air blowers to dissolve oxygen into	NO	YES
Require additional sub-network of AIR delivery to diffusers.	NO	YES
Able to use existing water pumps and pipe networks to	YES	NO
Require additional water pump to dissolve oxygen into the	YES	NO
The footprint of equipment used.	Very small	Large
Installation mobile and can be moved easily to different	YES	NO
Equipment maintenance burden	VERY LOW	VERY HIGH
Installation time	hrs	days
AIR temperature impact on DO performance	VERY LOW	VERY HIGH
AIR use design factor to reduce COD and BOD	not required	add 50% more AIR as normally required to break down BOD and COD
Risk of condensation in air-feed lines to reduce AIR-FLOW	No Risk	HIGH
Risk of water temperature rising due to high air	No Risk	HIGH
Risk of noise pollution.	No Risk	HIGH
Risk of scaling and biofilm affecting the efficiency of	No Risk	HIGH
Maximum installation depth of diffuser	Unlimmited	5 m

4.4.9 **Test 2 – Bubble size lifting particles in water.**

4.4.10 The efficacy of ultrafine bubbles in floating particles and contaminants can be attributed to their high surface-to-volume ratio, penetration ability, buoyancy, and collision efficiency. Although the bubble sizes that collided with the particles were not measured, the results of the tests demonstrated the ability of ultrafine bubbles to move particles evenly throughout the water column. The difference in particle tracks intensity between 0.000068 counts per square weight (cpsw) and 0.025 cpsw indicates a difference in the number of particle tracks detected, with the latter representing a higher level of particle movement.

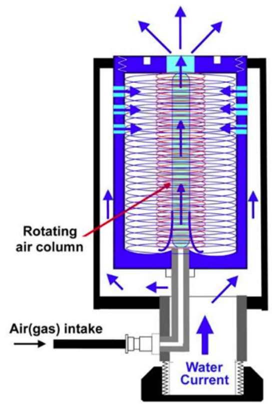
4.4.11 A comparison of the results from standing water in Figures 1 and 3 reveals that ultrafine bubbles raised particles with a maximum size of 45 microns, which is a significant finding considering that the unique characteristics of ultrafine bubbles only become evident when the bubble size is smaller than 100 to 65 microns.

4.4.12 It is important to note that the aeration efficiency of the MB/UFB technology will vary based on the number of UO2-MB/UFB units connected to the water pump. In this particular test, only one UO2 unit was connected to one pump.

5 UO2 MICRO and ULTRAFINE BUBBLE GENERATORS

5.1 Introduction.

5.1.1 UO2-SS-1N and UO2-uPVC-1N



5.1.2 Brief explanation of how the UO2-SS and PVC MB/UFB generators work:

The water is pushed from the outer shell chamber into the gas-liquid generating chamber via holes in the top of the inner chamber that forces the water to spin inside the gas-liquid generation chamber (first vortex) downwards. The chamber floor pushes the water up, creating a second vortex upwards and pushing the water out of the hole in the chamber ceiling.

The high velocity creates a negative-pressure cavity portion at the bottom of the inner chamber floor, naturally sucking in the air via the air supply line.

Micro and Ultrafine bubbles are created due to the shearing action of the swirling flow generated by the water squirted into the gas-liquid generating chamber.

5.1.3 The UO2-SS-1N _ 304 stainless steel MB/UFB generator was designed to be used in extreme water conditions, such as seawater, and the UO2-PVC-1N unit to meet farmers' request to have a more cost-effective unit. These MB/UFB generators release micro-and ultrafine bubbles.

5.1.4 It is recommended that the MB/UFB generator be used with a 0 to 5L/min manual airflow regulator and Dissolved Oxygen (DO) measuring equipment. It can be mounted on a submersible or via pipework to a land-based pump with the following spec: 0,6kW-80L/min-9,3mHead with a 50mm outlet.

5.1.5 Although the SS unit comes with a 5-year warranty and the PVC unit with a 1-year warranty, it is recommended to be cleaned when the pump is maintained according to the manufacturer's instructions. The system is an easy plug-play system that does not require changes to existing pipework. It can be installed within 1hrs without stopping any operations.

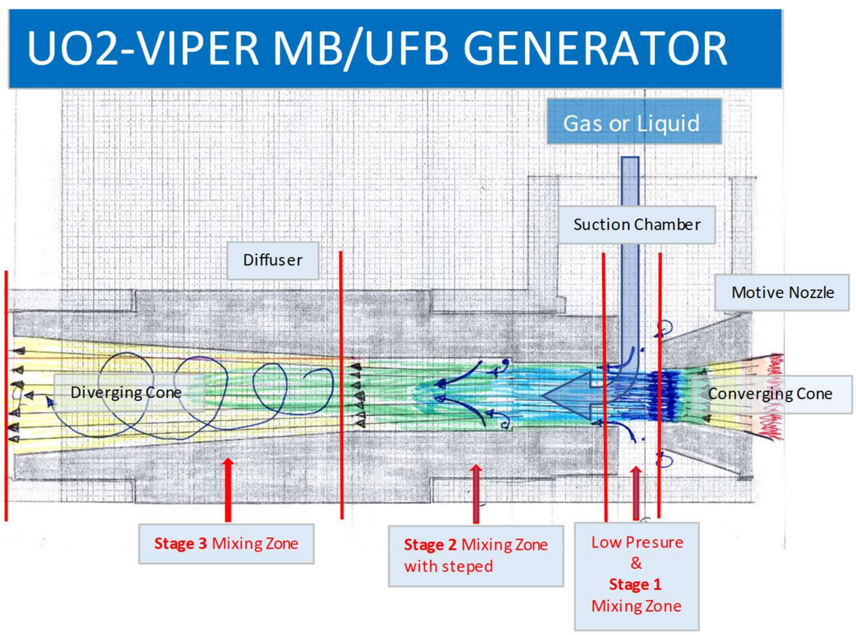
5.1.6 Its primary purpose is to raise and maintain Dissolved Oxygen (DO) levels in water and to drastically lower the Chemical Oxygen Demand (COD) in the water to ensure clients use the best quality water.

5.1.7 The maximum DO level achieved in water with an oxygen concentrator (using +- 90% oxygen) was 38 mg/L, and ambient air (using +- 20 % oxygen) was 9,2mg/L—both in freshwater with a temperature of 18,5 degrees Celsius.

5.1.8 The level of oxygenation required, the volume of water, the time to achieve the necessary level of Dissolved Oxygen, and the volume of water stored in reservoirs will determine the type and quantity of UO2 units required. Therefore, **site-specific engineering is recommended to determine the most effective solution for each project.**

These units produce more Ultrafine bubbles than Microbubbles.

5.2 UO2-VIPER



5.2.1 Brief explanation of how the UO2-VIPER MB/UFB generator works:

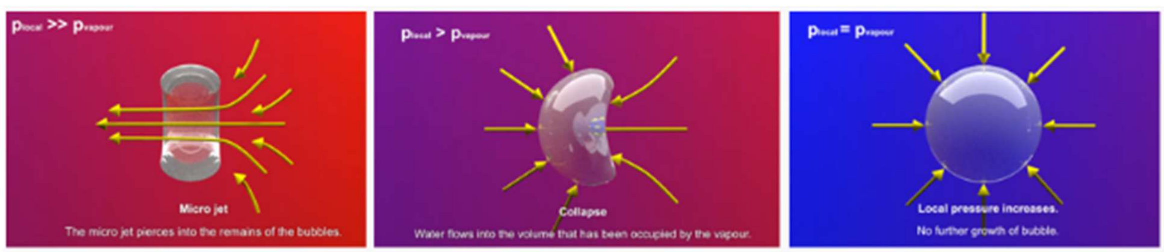
5.2.2 The UO2-VIPER MB/UFB generator is NOT A VENTURI and was designed to complement the UO2-SS-1N or the UO2-PVC-1N MB/UFB generators; after discovering that surplus pressure energy from the motive, fluid was available. This additional energy was used to design a solution able to multitask like no other aeration solution in the world.

5.2.3 Combining the functions of an ejector, injector, jet pump, vacuum generator, and venturi enabled the UO2-Viper to generate micro- and ultrafine bubbles, to add gas in a liquid, to add a liquid to a liquid, to use cavitation to assist with disinfection, and to improve the quality of mixing in of nutrients in the water.

5.2.4 Water flows into the UO2-Viper at a higher pressure than it exits. This pressure difference creates a vacuum at the suction port on the side of the device. This sucks air, oxygen, ozone, or liquid into the main water stream. So, the more significant the pressure difference, the greater the vacuum and, with that, the greater the mixing efficiency.

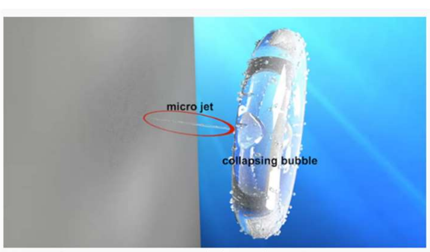
5.2.5 What makes the UO2-Viper unique is that in venturis, gas and liquid are pulled, via a hole unevenly, into a single mixing vortex, where in the Viper's case, the gas or liquid is received by a large suction chamber and feeds this evenly via the perimeter of the entrance hole of the diffuser that leads through to the diverging cone.

5.2.6 In the UO2-VIPER, the static pressures in the suction and mixing zone chambers can be decreased below the vapour pressure by as much as -90 kPa at a constant flow of water by reducing the airflow to the suction chamber, allowing water to evaporate in the formation of bubbles (Vapor bubble grows at low pressure). It collapses within milliseconds in a spectacular physical event as it is transported with the flow from where it was formed at low pressure to areas with higher pressure. The bubble will stop growing when local pressure exceeds vapour pressure, and because liquid water occupies many thousand times less volume than vapour, the bubble implodes.

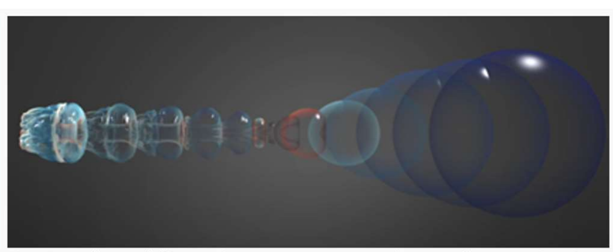


5.2.7 Also known as cavitation, the water is forced to become water vapour by the physical creation of micro vacuums "bubbles" underwater. These "bubbles" are made of water vapour only. No air or gasses are involved. These "bubbles" entirely collapse to form liquid water again. The jet velocity can reach up to hundreds of m/s.

5.2.8 It must be noted that cavitation does not increase DO levels in the water. However, due to the ability to create a negative pressure up to -90 kPa in the suction chamber, the **UO2-Viper MB/UFB generator can raise DO levels and use Cavitation simultaneously** in water with a temperature of 10 degrees Celsius.



Gas is entrapped by the jet.



Recirculated liquid propagates along the main jet

5.2.9 In general, cavitation is one of the elements of an integrated treatment system consisting of physical, chemical, and biological processes.

5.2.10 The effects of cavitation have become very useful in supporting chemical processes in environmental protection technologies, especially in technologies related to the decomposition of substances particularly harmful to humans and their immediate surroundings.

5.3 Benefits expected:

It improves coagulation and flocculation, drops zeta potential, increases oxidation potential that helps to remove bacteria and parasites, raptures their cell walls, and then kills them by oxidation.

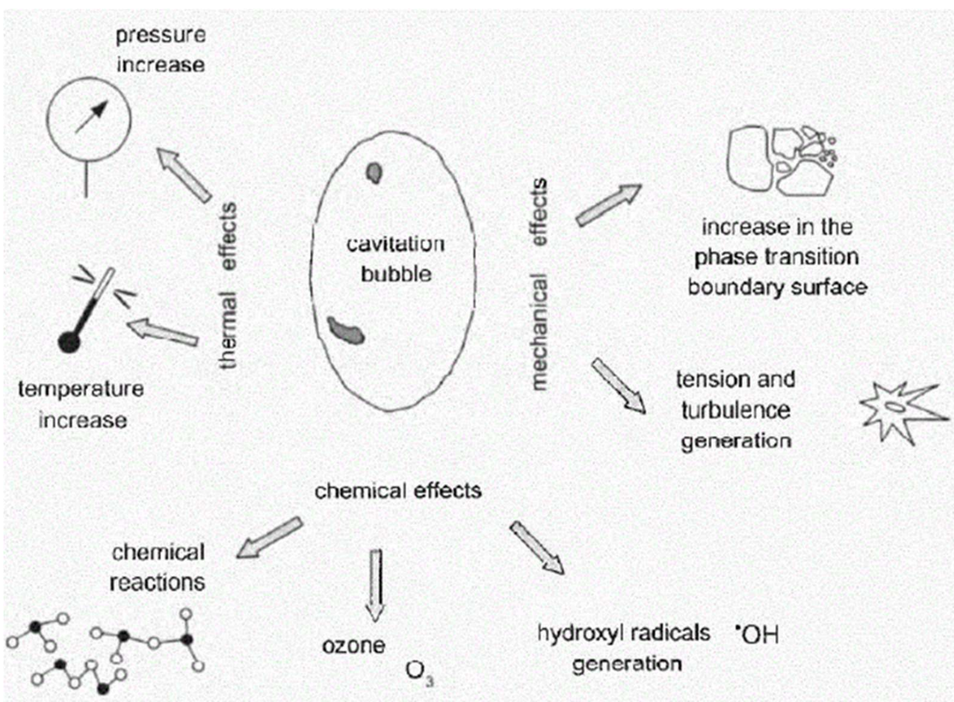
It increases the biodegradability of organic compounds in polluted water—exhibits bactericidal activity during water treatment.

Decrease the amount of persistent organic pollutants in wastewater treatment plant effluent.

Biological disinfection of water.

Destructive effect on yeast, bacteria and even viruses.

For example, the combination of cavitation and H2O2 reduces suspended TOC values of tannery wastewater more than only using H2O2.



5.3.1 The UO2-SS combined with the Viper on one pump can, therefore, do the following:

UO2 MB/UFB GENERATORS
TECHNICAL DETAILS

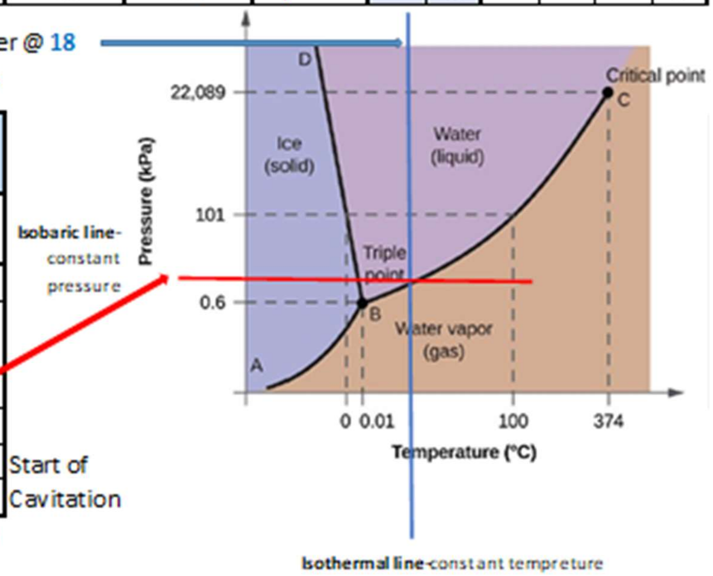
	SS/PvC-1N	VIPER			SS/PvC-1N		VIPER			
Volume of water used	46 L/min	60 L/min		Uses	Gas Injection	Liquid Injection	Gas Injection	Liquid Injection	Disinfection	Mixing
Gas	3.5 L/min	14 L/min		Option 1	x		x			
Liquid	1.3 L/min	1.8 L/min		Option 2		x		x		
DO-Ambient air (21% O_2)	**9.21 mg/L**	**8.57 mg/L**		Option 3	x			x		
DO - Oxygen Concentrator (90% O_2)	**38 mg/L**	**28 mg/L**		Option 4		x	x			
Minimum requirements for pumps				Option 5	x				x	
Type	**(kW)**	**(m)**	**(L/min)**	Option 6	x					x
Submersible	0.4	9.3	80	Option 7		x			x	
Land-Base	0.37	10	183	Option 8		x				x

Water - clean freshwater @ 18 degrees Celsius

Vacuum Chamber Airflow Data	
Presure (kPa)	**Gas Flow (L/min)**
0	14
-15	12
-34	10
-63	6
-85	4
-90	0.5

Start of Cavitation

Presure adjustable by turning down gas flow



5.3.2 The UO2 and VIPER can be used independently from each other in different locations in an irrigation system.

5.3.3 This unit produces more Micro bubbles than Ultrafine bubbles

5.3.4 It is recommended that the MB/UFB generator be used with a 0 to 20 L/min manual airflow regulator and Dissolved Oxygen (DO) measuring equipment. It can be mounted on a submersible or via pipework to a land-based pump with the following spec: 0,6kW-80L/min-9,3mHead with a 50mm outlet.

5.3.5 The unit comes with a 1-year warranty. The system is an easy plug-play system.

5.3.6 Its primary purpose is to raise and maintain Dissolved Oxygen (DO) levels in water and to use the benefits of cavitation for mixing and disinfection purposes.

5.3.7 The maximum DO level achieved in water with an oxygen concentrator (using +- 90% oxygen) was 28 mg/L, and ambient air (using +- 20 % oxygen) was 8,57mg/L in freshwater with a temperature of 18,5 degrees Celsius.

5.3.8 The level of oxygenation required, the volume of water, and time to achieve the necessary level of Dissolved Oxygen, and the volume of water stored in reservoirs, will determine the type and quantity of UO2 units required. Therefore, site-specific engineering is recommended to determine the most effective solution for each project.

6 CLOSE-OUT COMMENTS

6.1.1 Oxygen and Micro and Ultrafine bubbles are necessary elements in all forms of life. The level of dissolved oxygen (DO) is one of the best indicators of overall water quality.

6.1.2 Ultra-Oxygen equipment is the best candidate for the addition of oxygen to aeration systems, due to its low power consumption. The ORT per kWh is very low compared to existing diffusers.

6.1.3 UO2-MB/UFB generators are the world's best-priced, most cost-effective, sustainable, robust, easy to use, and most environmentally friendly way to create Micro- and Ultrafine bubbles smaller than 100 microns.

"It is crucial for humans to manage oxygen in the water to save our planet's blue gold."

7 YOUR POINT OF CONTACT

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