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AQUAPONICS
MICRO and ULTRAFINE BUBBLE
DISSOLVED OXYGEN (DO)
CASES STUDY

For

PRACTICAL AQUAPONICS
...growing for life...

Practical Aquaponics (Pty)Ltd

Project

Report 1_Revison 2_07 October 2022

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1 INTRODUCTION

1.1 About Soldevco Pty Ltd and Ultra-Oxygen

1.1.1 SOLDEVCO/Ultra-Oxygen is the sustainability partner for those serious about making changes that will lead to long-term benefits for themselves and the planet. We work together towards a GREATER, GREENER future by providing cutting-edge advice and tech.

1.1.2 We are a solution-driven firm dedicated to providing solution-focused services for projects and clients serious about water quality and the environment.

1.1.3 The critical thing to remember is that SOLDEVCO/ULTRA-OXYGEN is all about COLLABORATION, so every task, opportunity, challenge, and setback is taken on with a mindset and an attitude that says,

"*WE ARE IN THIS TOGETHER*".

1.2 Problems or issue's shared with us by the farmer

1.2.1 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 quick enough when dissolved oxygen losses are experienced.

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

1.2.3 The current "nanobubble" technology system can only work outside the present water recycling system because the biology clogs up the probe. Adding "High-DO" water to the network is thus only possible via "dozing" high-enriched oxygenated water to the circulation system. This is <u>not sustainable</u> since this increases the amount of water required and forces the farmer to discard nutrient-enriched water to make space for the volume of water needed to raise the DO level.

1.2.4 The best-dissolved oxygen levels achievable using air stones are in the region of 6,5 mg/L @ 16deg

1.2.5 Energy used by the air pumps connected to round air stones in the water beds +- 750W/hr (18 kW/day)

1.2.6 Energy used by the air pumps connected to round air stones in the fish tanks +- 400W/hr (9,6 kW/day)

1.2.7 Energy used by the air pumps connected to round air stones in total +- 1 500W/hr (36 kW/day)

1.3 Goals / Metrics / Objectives the farmer would like to achieve

1.3.1 Observing the climate changes and global warming's impact on the ecosystem, decreasing aqua animal stocks, and responding to increasing demand are turning points in the sustainability era.

1.3.2 In the past 15 years, fish production has doubled, thus denoting that aquaponics will transform into commercial scales with a revolutionised production, high efficiency, and fewer resource utilisation, thus requiring proper sustainable operation and management standards and practices.

1.3.3 Since aquaponics systems are self-regulating, they have less impact on the ecosystem, as they use limited environmental contents (use of external organics, chemicals, fertilisers, antibiotics, and reducing freshwater consumption and wastewater discharge).

1.3.4 According to the report by [*Simke, A. Aquaponics Presents a New Way to Grow Sustainable Fish and Veggies. Forbes* ***2020***.], 70% of the freshwater consumed globally for food production can be saved by 30–70% using efficient irrigation systems and 90% using aquaponics systems.

1.3.5 Therefore, it's crucial for the farmer:

- to be able to have aeration equipment that does not glogg up and is 100% reliable and sustainable,
- to invest in equipment that adds value and reduces the risks of running into problems caused by anaerobic conditions.
- to have equipment and water monitoring equipment that securely provides an even dissolved oxygen level, preferably equal to or better than its best of 6,5 mg/L but not higher than 10mg/L.
- To reuse water for more extended periods at higher quality.

1.3.6 This case study will test the UO2 Micro and Ultrafine bubble generators to see if they can achieve the high goals set by the farmer.

1.3.7 The case study will also explore the best ways to incorporate the UO2-MB/UFB technology in the current design framework and to provide a new sustainable mechanism for designing and implementing sustainability-efficient aquaponics and aquaculture systems.

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

1.4.1 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.

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

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

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

1.4.5 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.

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

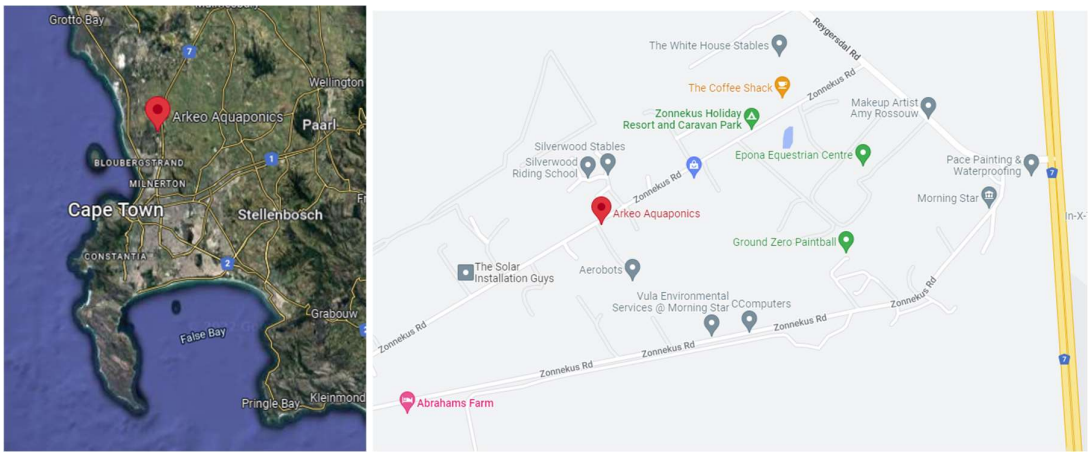
1.4.7 To improve the ability to reuse water, the "Blue Gold" of the planet.

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

2 SITE VISIT INFORMATION

2.1 Site Location

2.1.1 Arkeo Aquaponics, 52 Zonnekus Road, is situated in Morning Star, Cape Farms, Western Cape South Africa, 30 minutes drive from Cape Town.



2.2 Operations and Site information

2.2.1 From our site visit – During our visit in August and September 2022, we observed the following.

2.2.2 The neat and well-managed farm was divided into three sections that operated independently from each other. Each unit consisted of 4 Fish Tanks grouped with one 5 000 L sump feeding the media beds, feeding three water beds. (12 fish tanks – 3 Sumps – 9 Water beds)

2.2.3 This time of the year, the farm experienced the best-dissolved oxygen levels in the water. The measurements taken on 5 August showed maximum DO level of 6,85 mg/L @ 15 degrees Celsius, and on 1 September 2022, 6,58 mg/L @ 16,4 degrees Celsius.

2.2.4 Considering that the farm is also used for educational purposes and was in immaculate shape, it can be assumed that the current designed system performed at its best. This, on its own, provided a good challenge for the UO2-MB/UFB technology.

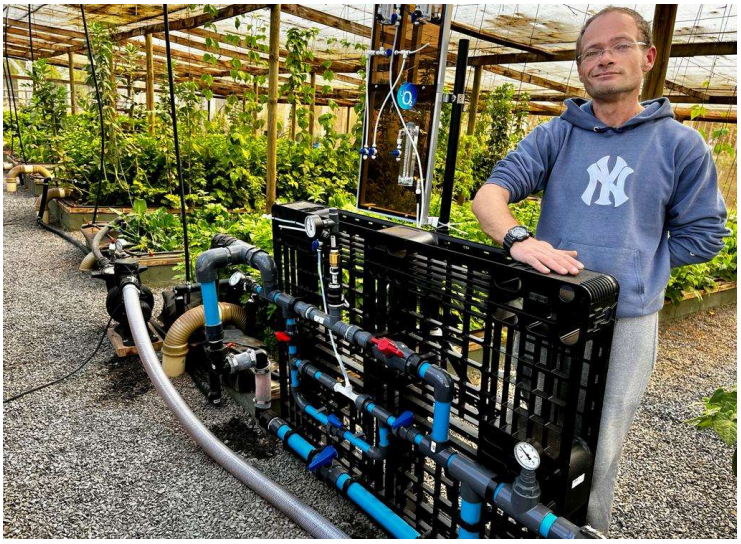
3 THE CASE STUDY

3.1 Methodology

3.1.1 Section 1 of the farm remains untouched by any tests. (**CONTROL**).

3.1.2 Section 2 received the UO2-SS-1N MB/UFB generator in the sump. (**TREATED – UO2**)

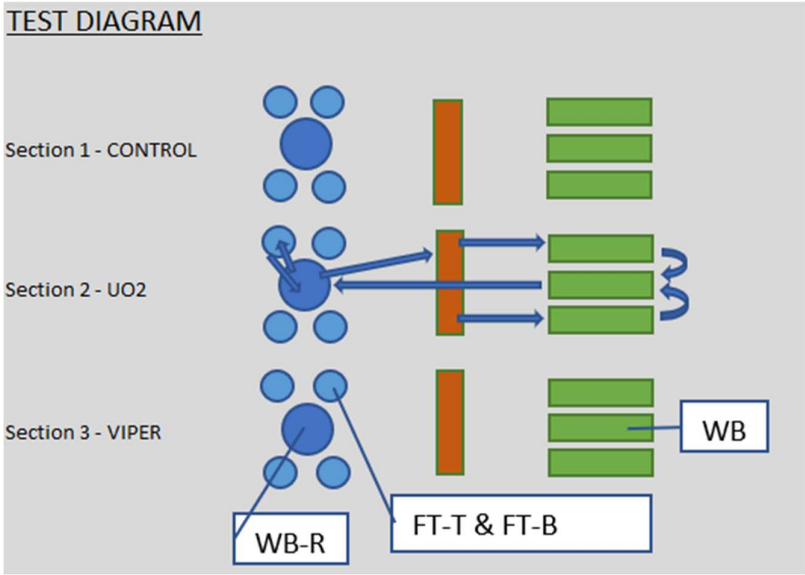
3.1.3 Section 3 received the UO2-Viper MB/UFB generator. (**TREATED – VIPER**)



3.1.4 The case study was started on 1 September 2022, and DO levels were taken of the water obtained from the following locations in each section.

- At the fish tank area
  - Top of the fish tank (FT-T)
  - Waterbed Return (WB-R)
  - Bottom of the fish tank (FT-B)
- At the waterbeds
  - From the top section of the middle waterbed received water from the two waterbeds. (WB)

3.1.5



3.1.6 First Phase Test - Ambient air was used during the first phase of the test to determine if DO levels can be raised above the current good values of 6,58 mg/L.

3.1.7 Second Phase Test +- 90% Oxygen was used in the second phase of the test to determine how quickly the DO levels could be raised to the maximum value that can be maintained to ensure DO levels in the waterbeds but not allowing the fish tank DO levels to go higher than 10mg/L.

3.1.8 The tests include the results of how the DO levels will vary in the current design when raised, considering the position of the MB/UFB generator.

3.1.9 After a safe, high DO is reached, record the DO time to drop to 7.5mg/L at the area where the UO2 equipment was installed and switched off.

3.1.10 Record final readings one day after the system is switched off.

3.1.11 Record reading in section 3 after running UO2 and VIPER on ambient air after completing Phase 2 tests.

3.2 Case study results

3.2.1 First Phase Test - Ambient air was used during the first phase of the test to determine if DO levels can be raised above the current good values of 6,58 mg/L. **The results indicated that ambient air could improve DO levels by at least 37%.** The maximum DO level reached was 7.98mg/L.

Project: **ARKEO-AQUAPONICS**

			START PHASE 1 Tests	Ambient Air (21% Oxygen)		STOP PHASE 1 Tests	
		Date	01 Sep 22	03 Sep 22	05 Sep 22	06 Sep 22	**5 Day**
		Time	12:30	12:30	17:30	11:30	**Variance**
Section 1-Control	Fish Tank (from top) **FT-T**	DO	6.55	6.12	6.98	6.75	3.05%
Average DO at START		Temp	17.2	17.1	17.2	15.7	-8.72%
6.385	Waterbed Return **WB-R**	DO	6.14	6.32	6.388	**6.93**	**12.87%**
Average DO at END		Temp	16.2	16	16.8	14.9	-8.02%
6.65	Fish Tank (from bottom) **FT-B**	DO	6.27	6.07	6.52	6.38	1.75%
4.15%		Temp	17	17	17	15.9	-6.47%
Increase	Waterbed (top of return bed) **WB**	DO	6.58	6.52	6.71	6.54	-0.61%
		Temp	16.4	15.7	16.8	15.1	-7.93%
Section 2-UO2	Fish Tank (from top) **FT-T**	DO	6.08	7.15	7.25	7.48	**23.03%**
Average DO at START		Temp	17.2	17.4	17.2	15.4	-10.47%
6.205	Waterbed Return **WB-R**	DO	6.3	6.52	6.88	**7.62**	20.95%
Average DO at END		Temp	16.5	16.4	16.8	15.2	-7.88%
7.31	Fish Tank (from bottom) **FT-B**	DO	6.42	6.33	6.61	7.29	13.55%
17.81%		Temp	17.4	17.3	17	15.4	-11.49%
Increase	Waterbed (top of return bed) **WB**	DO	6.02	6.37	6.51	6.85	13.79%
		Temp	16.6	16.2	16.8	14.5	-12.65%
Section 3-VIPER	Fish Tank (from top) **FT-T**	DO	6.63	7.14	6.85	**7.98**	20.36%
Average DO at START		Temp	17.2	16.5	17.2	15	-12.79%
6.265	Waterbed Return **WB-R**	DO	6.55	7.12	6.62	7.87	20.15%
Average DO at END		Temp	16.4	16.4	16.8	15.1	-7.93%
7.8025	Fish Tank (from bottom) **FT-B**	DO	6.46	6.85	6.95	7.93	22.76%
24.54%		Temp	17	17.1	17	15	-11.76%
Increase	Waterbed (top of return bed) **WB**	DO	5.42	9.93	7.22	7.43	**37.08%**
		Temp	16.7	16.2	16.8	14.5	-13.17%

3.2.2 It was clear from the test that the conditions in the fish tank area, Section 2-UO2, had a negative impact on raising the DO level. This is mainly due to the humidity and available surface area in the sump for oxygen to escape and the 1-degree Celsius difference between the water in the waterbed of Section 3-VIPER and the sump in Section 2-UO2.

3.2.3 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. It was expected that the DO levels might rise due to the distance and speed the bubbles move through the system.

Project: **ARKEO-AQUAPONICS**

			START PHASE 2 Tests	Oxygen Generator (90% Oxygen)		STOP PHASE 2 Tests				STOP CASE STUDY
		Date	06 Sep 22				Maximum DO	System	06 Sep 22	07 Sep 22
		Time					after stop	OFF	15:39	15:30
Section 1-Control	Fish Tank (from top) **FT-T**	DO								6.53
Average DO at START		Temp								16.6
6.385	Waterbed Return **WB-R**	DO								6.94
Average DO at END		Temp								16.7
6.65	Fish Tank (from bottom) **FT-B**	DO								6.43
4.15%		Temp								16.88
Increase	Waterbed (top of return bed) **WB**	DO								6.16
		Temp								16.8
Section 2-UO2	Fish Tank (from top) **FT-T**	DO							6.85	6.65
Average DO at START		Temp							16.7	16.3
6.205	Waterbed Return **WB-R**	DO	7.62	**duration**	**9 min**	9.5	**9.85**	1hr 10min	**7.45**	**7.38**
DO at END		Temp				16.4			16.8	16.2
9.85	Fish Tank (from bottom) **FT-B**	DO							6.85	6.74
58.74%		Temp							16.7	16.3
Increase	Waterbed (top of return bed) **WB**	DO							6.83	6.54
		Temp							16.2	16.2
Section 3-VIPER	Fish Tank (from top) **FT-T**	DO							8.2	7.51
Average DO at START		Temp							15.9	16.8
6.265	Waterbed Return **WB-R**	DO							8.48	7.41
DO at END		Temp							16.2	16.9
11.5	Fish Tank (from bottom) **FT-B**	DO							7.98	7.66
83.56%		Temp							16.2	16.8
Increase	Waterbed (top of return bed) **WB**	DO	7.43	**duration**	**20 min**	9.56	**11.5**	2hr 10min	**7.5**	**6.55**
		Temp				15.1			15.88	16.4

3.2.1 **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)

3.2.2 The results showed that the UO2 in its position in Section 2-UO2 could be set to run 10min every 1hr 10min, and the VIPER in its place in Section 3-VIPER can be set to run 20min every 2hr 10min. The current air supply system runs with 600w over 24hrs. Thus approximately 14 400w is used a day. If 3pumps are used at 1200w over 5 hrs, about 6 000w will be used daily. Worse case, will it result in a +- 60% drop in energy usage.

3.2.3 It must be noted that an ESKOM power outage from 10:20 am on 7 September 2022 had various influences on the final reading taken later at 15:50. Taking into consideration that some of the waterbeds were receiving no air for a period of +- 5 hrs before the readings were taken, it appears that the oxygen in the Micro and Ultrafine bubbles generated by the UO2-MB/UFB generators were helping to keep the oxygen above the highest level achieved without the use of the technology.

3.2.4 The test results provided valuable information on where the best place would be to inject the Micro and Ultrafine bubbles. When oxygenated MB/UFB is injected in the waterbeds, a dosage of 11.5mg/L will result in an 8.5mg/L reading downstream in the fish tanks. Theoretically, it can thus be assumed that a dosage of 12,5mg/l will result in a 9,5mg/L reading. This is good news for the plants and the fish, who prefer less oxygen than the plants.

The results also showed that the floating rafts trapped the oxygen in the water and could limit oxygen escape in terms of Henry's Law. Water temperatures were also lower in the waterbeds, favouring higher DO levels. The ambient air temperature above the water in the fish tank was +- 33 degree Celsius compared to the 17 degrees Celsius at the waterbeds, which also favours higher DO levels.

3.2.5 A 100% oxygen level improvement was easily achieved with the UO2-MB/UFB technology.

3.2.6 A 60% drop in energy costs is possible while enjoying the system's 100% increase in oxygen levels.

4 CONCLUSION & RECOMMENDED SOLUTION/S

4.1 Motivation/Justification for recommended solution/s

4.1.1 The increased production of fish is mostly constrained by inadequate water quality. Optimal environmental conditions will affect the success of fish production in aquaculture activities. Aquaculture activities produce solid and liquid waste from manure and fish food waste, decreasing water quality and affecting fish's physiological processes, behaviour, growth, and death. Innovation and technological inputs are required to anticipate aquaculture production and productivity decline. Technological innovation is needed to overcome these problems; one of the technologies that can be used in aquaponics is UO2-MB/UFB generators.

4.1.2 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.

4.1.3 Adding aeration to the recirculation system can accelerate the nitrification process action. Aeration in aquaculture has the function of dissolving oxygen into the water to increase dissolved oxygen concentration, reduce the concentration of unneeded gases dissolved in water, and help stir the water.

4.1.4 UO2-MB/UFB generators are a technology that produces bubbles to provide dissolved oxygen for a long time and in stable conditions. MB/UFB application has a positive effect on fish farming activities, including fish growth being much faster, fish are not susceptible to disease, and water quality is maintained even in closed pond systems (water is circulated continuously).

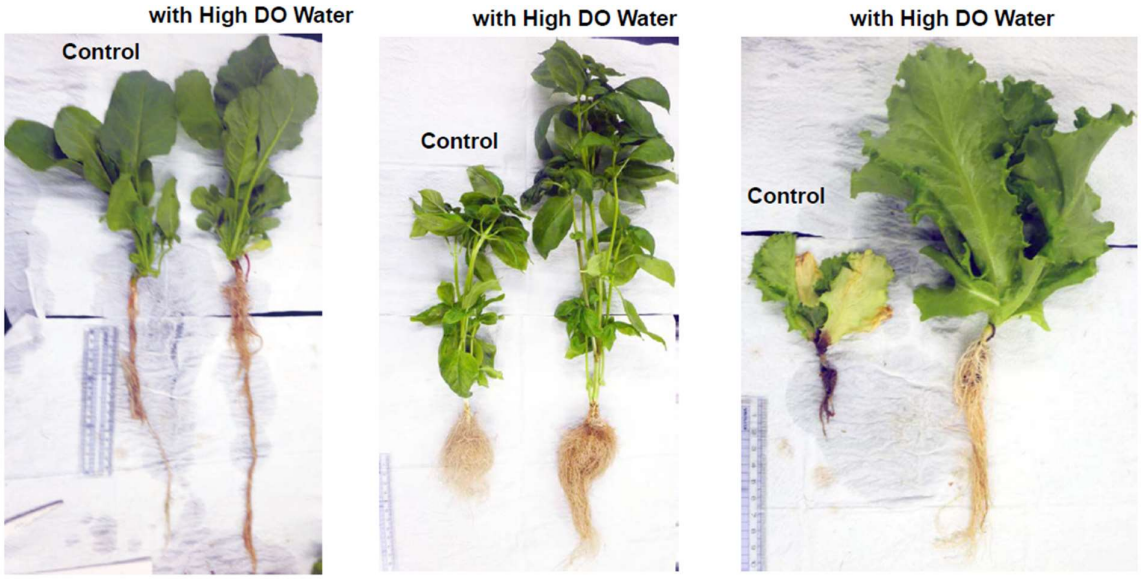
4.1.5 UO2-MB/UFB generators are designed to control the bubble size distribution by controlling the airflow to the generator. The combination of pressure and airflow rate affects the bubbles' size. The size of the bubbles will affect the concentration of dissolved oxygen.

4.1.6 Fish survival is one indicator of whether the cultivation system is feasible. This is because the survival of fish is related to the adequacy of food, the health of the fish, and good or poor environmental maintenance, such as water quality. The aquaponics system reduces the waste by absorbing the wastewater using plant roots so that the remaining absorbed feed undergoes an oxidation process with the help of oxygen and bacteria. Increasing oxygen concentration is an alternative to reducing ammonia concentration in water. The nitrification process is more efficient under conditions of high oxygen tension. High oxygen concentrations can oxidise ammonia so that it does not become toxic in water.

4.1.7 The smaller the diameter of the bubbles increases the resistance of the bubbles in the water and ultimately improves the gas transfer and solubility of dissolved oxygen. The small diameter of oxygen-filled Micro and Ultrafine bubbles (MB/UFB) increases the surface area of water that coincides with air, making it easier to process air diffusion to water. The higher diffusion level accelerates the process of oxygen saturation. Using MB/UFB-sized bubbles in fish-rearing media will increase dissolved oxygen concentration, accompanied by improved water quality in aquaculture containers. The excellent oxidation process causes sufficient nitrogen concentration and stimulates plant growth.

4.1.8 Internal and external factors influence plant growth. Internal factors that affect plant growth are related to physiological processes, while external factors influence sunlight radiation, water temperature, and nutrient supply.

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



Spinach **Basil** **Lettuce**

4.1.10 Due to the fish's maximum oxygen constraint in the aquaponics system, you cannot supersaturate the water. You can only use a DO level of up to +-10mg/L. Thus we can only expect similar results over a more extended period. In any event, the results predicted will be better than those obtained previously without UO2 MB/UFB technology.

4.1.11 Maintaining the sustainability of aquaponics system resources is the central part of the system lifecycle. Now, by adding the missing link, UO2 Micro, and Ultrafine bubble dissolved oxygen technology, the risks of failures are less, and the rate of your ROI is higher.

4.1.12 **Ultra-Oxygen not only met the farmer's demands but exceeded them by as much as 100%, and thus believes that we can become a valuable partner in the Aquaponics industry and that our UO2-MB/UFB generators will change the face of aquaponics worldwide over time.**

4.1.13 The contribution of aquaponics and aquaculture systems to world food supply and nutritional security has been reported intensely for the last two decades. In addition to optimally producing aqua products, integration of aquaponics and aquaculture into the global food system in terms of quantification, valuation, and market development in the way of sustainable development persists, with a dramatic impact on world nutrition security and marine ingredients, and reliance on the terrestrial ecosystem has remained rare.

4.1.14 This essential case study effort emphasises that sustainability requirements include reporting aquaponics and aquaculture, idealising and conceptualising, modelling, designing, management, and aligning these requirements within technical, technological, economic, ecological, environmental, and institutional sustainability pillars.

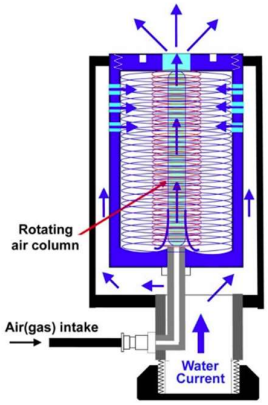
4.1.15 **Ultra-Oxygen** believes that we **hold the ultimate key to aquaponics success** , drastically improving the balancing of resources, processes, tools, and techniques that play a vital role in aquaponics and aquaculture sustainability, as shown below.

4.1.16 The cost-effective robustness and ease of use of the UO2-MB/UFB generators that provide cost savings on the aeration energy usage of +- 50% while enjoying the minimum of 100% increase of oxygen in the system must have a significant impact on aquaponics in future.

4.1.17 Further case studies would be recommended to improve aquaponic farming methodology incorporating UO2-MB/UFB technology.

4.2 UO2-MB/UFB GENERATORS USED & INFORMATION

4.2.1 UO2-SS-1N and UO2-uPVC-1N



4.2.2 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.

4.2.3 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.

4.2.4 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.

4.2.5 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.

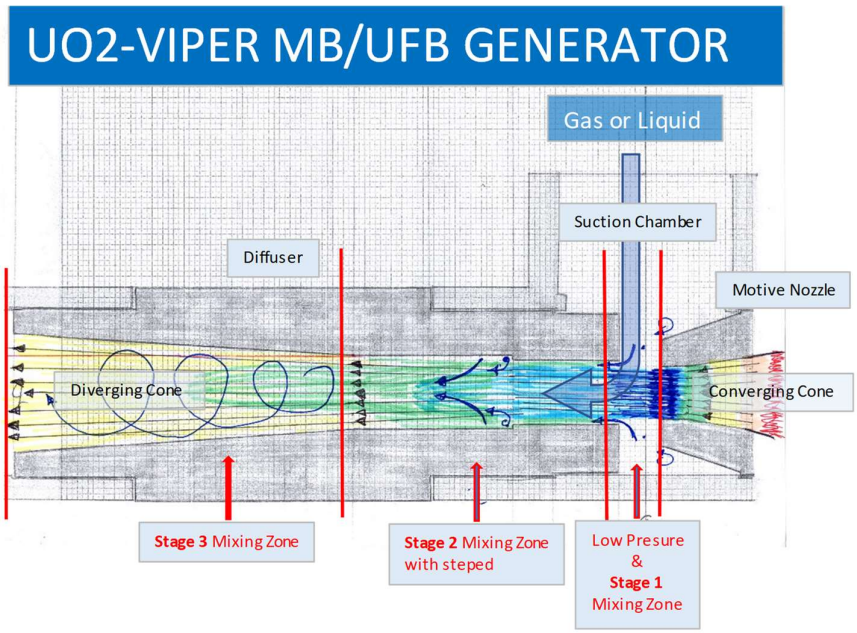
4.2.6 Its primary purpose is to raise and maintain Dissolved Oxygen (DO) levels in water and to drastically lower the Chemical Oxygen Demand (COD) in the water to ensure clients use the best quality water.

4.2.7 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.

4.2.8 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.

4.2.9 UO2-VIPER



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

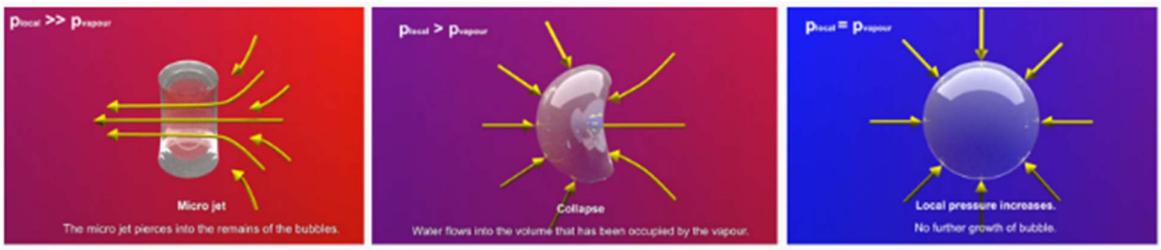
4.2.11 The UO2-VIPER MB/UFB generator is NOT A VENTURI and was designed to complement the UO2-SS-1N or the UO2-PVC-1N MB/UFB generators; after discovering that surplus pressure energy from the motive, fluid was available. This additional energy was used to design a solution able to multitask like no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

4.2.12 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.

4.2.13 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.

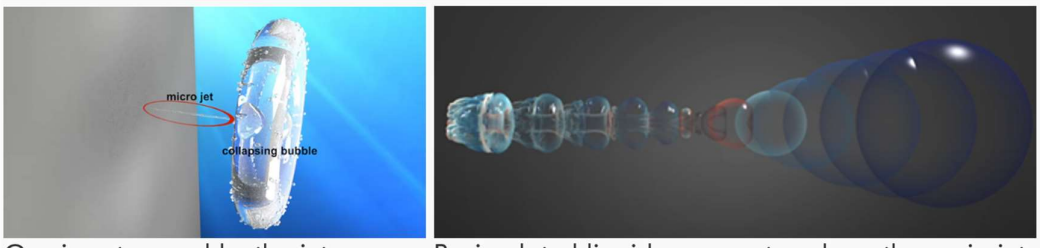
4.2.14 What makes the UO2-Viper unique is that in venturis, gas and liquid are pulled, via a hole unevenly, into a single mixing vortex, where in the Viper's case, the gas or liquid is received by a large suction chamber and feeds this evenly via the perimeter of the entrance hole of the diffuser that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

4.2.15 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.



4.2.16 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.

4.2.17 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

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

4.2.19 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.

4.2.20 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.

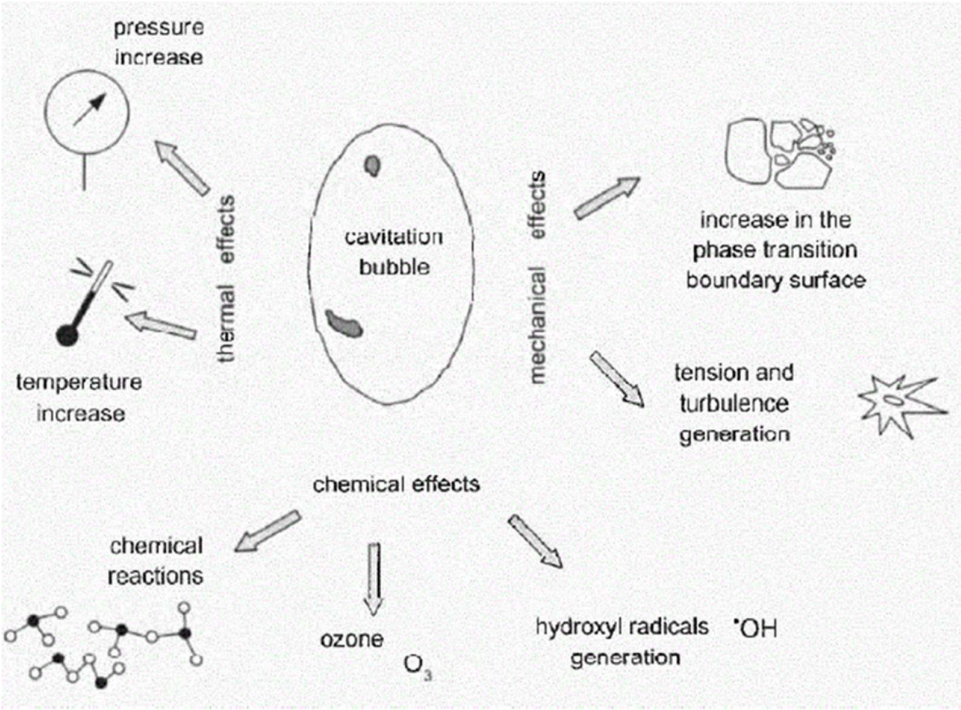
It increases the biodegradability of organic compounds in polluted water—exhibits bactericidal activity during water treatment.

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.



4.2.21 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

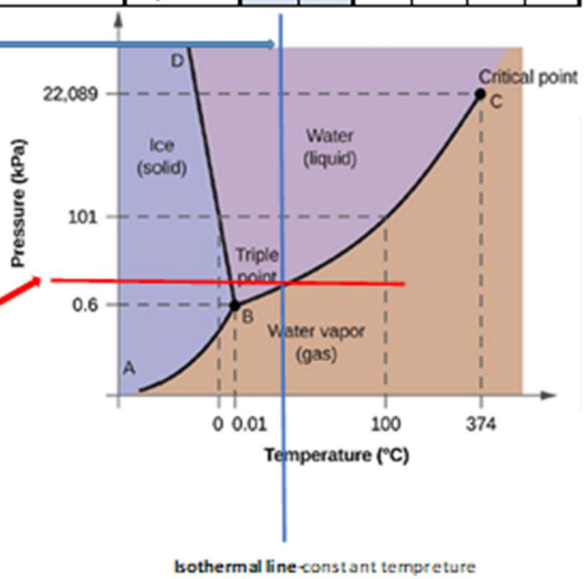
Water - clean freshwater @ 18 degrees Celsius

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

Isobaric line- constant pressure

Start of Cavitation

Presure adjustable by turning down gas flow



Isothermal line-constant tempreture

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

4.2.23 This unit produces more Micro bubbles than Ultrafine bubbles

4.2.24 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.

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

4.2.26 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.

4.2.27 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.

4.2.28 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.

4.3 Suggested solution for design upgrades

4.3.1 After observing the operational tasks and reviewing the current design principles, we recommend that a portable and fixed in-line solution be used.

Portable solution

Used one UO2-PVC MB/UFB generator mounted on one submersible pump with one 0-5L/min oxygen concentrator to improve oxygen levels in any area of the aquaponics system.

Fixed in-line solution

Used one UO2-Viper connected to pipework linked to one land-based pump for each set of waterbeds. In the case of Arkeo Aquaponics, it will result in 3 sets. All three sets can be connected to one 0-10L/min oxygen concentrator to improve oxygen levels in all the waterbeds.

5 CLOSE-OUT COMMENTS

5.1.1 Oxygen is a necessary element in all forms of life. The level of dissolved oxygen (DO) is one of the best indicators of overall water quality.

5.1.2 The dissolution of oxygen into the water is maximised with the injection of UO2 micro- and ultrafine bubbles. This is because tiny bubbles present a greater relative surface area to the surrounding water than larger bubbles. Oxygen diffuses into the water at the surface, so a large surface area facilitates excellent oxygen absorption.

5.1.3 UO2-MB/UFB generators are the 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.

6 YOUR POINT OF CONTACT

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