

SimpleScience

“Understanding science simply”



Simple Science

- In this edition of SimpleScience, I would like to explain some misconceptions about nanobubbles. Unfortunately, like many scientific discoveries, we too easily buy into the new science that may be unfolding. Many articles and research are put forth into the public domain, and we are expected to ferret out the truth and good science from the fantastic claims being made, nanobubbles are no different!
- Let's delve into several assertions commonly found in various articles and research. I have also conducted some straightforward tests on these claims to verify the potential benefits of nanobubbles. Additionally, I aim to debunk a few myths along the way.
 - **nanobubble diffusion/dispersion in a liquid**
 - **longevity of nanobubbles**
 - **nanobubble oxygenation of soils**

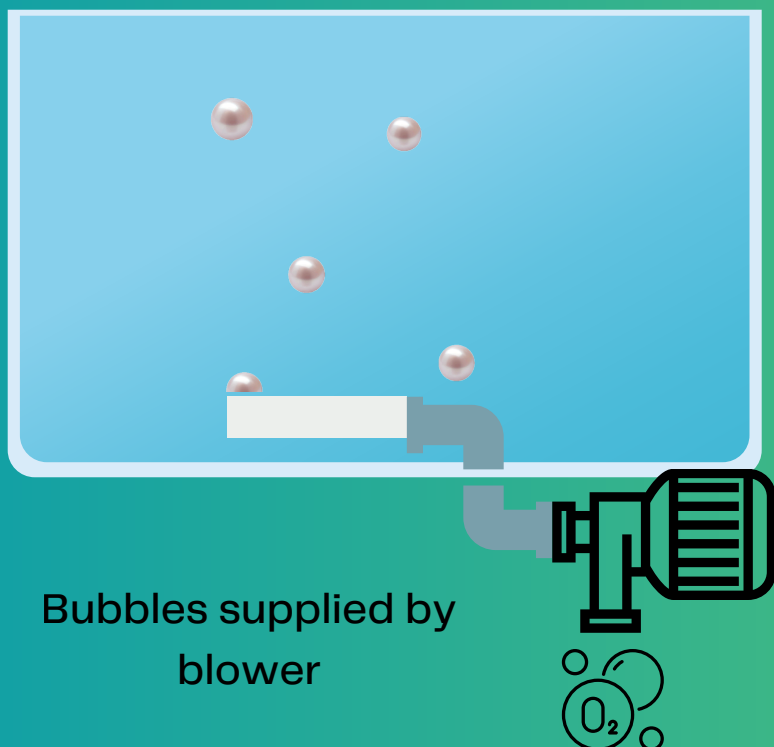
Nanobubble diffusion/dispersion in a liquid

- One fascinating aspect of nanobubbles is their ability to move through a body of water without quickly rising to the surface, unlike most bubbles!
- Here's the buoyancy rate for various bubble sizes:
 - A nanobubble measuring 200 nm exhibits virtually no rise rate,
 - A bubble at 10 μm rises at approximately 0.2 mm/min,
 - A 100 μm bubble ascends at about 326 mm/min,
 - A millimeter-sized bubble can rise at a remarkable 2400 mm/min.

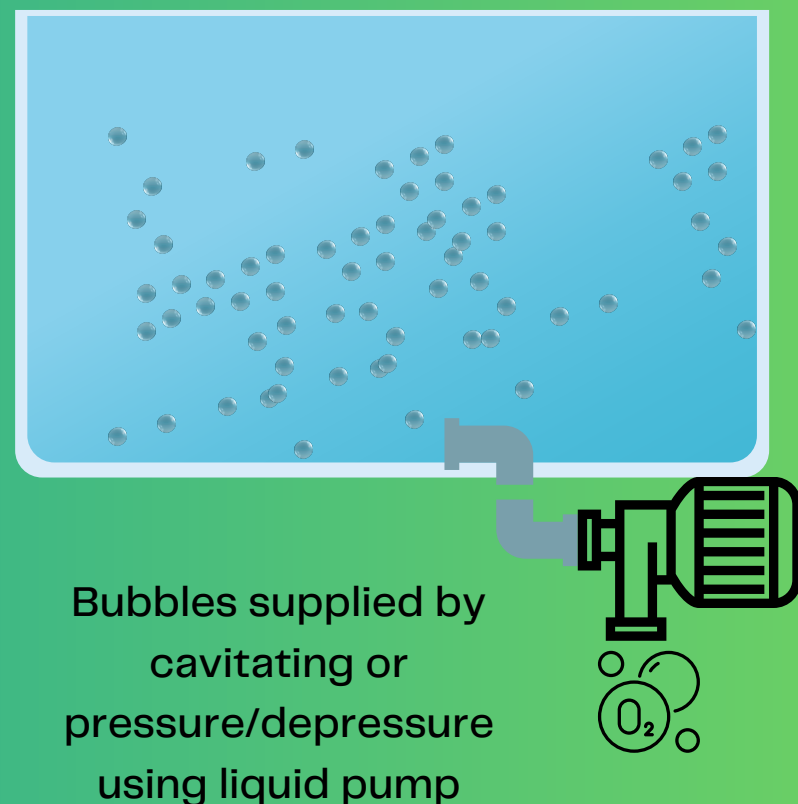
In a 10-foot deep tank of water, 100 μm microbubbles would reach the surface in 9 minutes, while millimeter-sized bubbles would take only 1.5 minutes! In contrast, nanobubbles may take weeks to surface.

Conventional aeration with microbubbles vs nanobubbles

Micro/Fine bubble diffuser

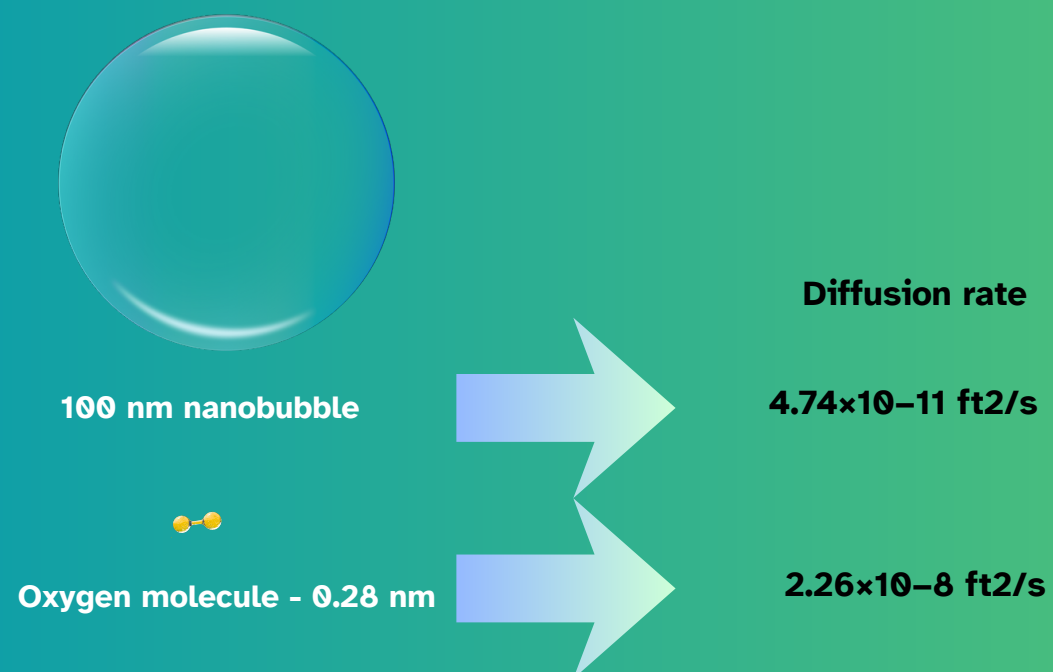


Nanobubble discharge



Nanobubble dispersion vs dissolved oxygen in a liquid

- Due to their random movement caused by Brownian motion, nanobubbles will disperse or diffuse throughout the water volume. Many assertions suggest that nanobubbles quickly diffuse in water because of their negative surface charge; however, I don't believe the scientific evidence supports this claim.
- Research indicates that dissolved oxygen diffuses more rapidly than nanobubbles, primarily due to size differences: the oxygen molecule measures approximately 0.28–0.35 nm in diameter, while most nanobubbles range from 20 to 200 nm.
- This suggests that dissolved oxygen indeed diffuses faster than nanobubbles. It's also important to note that any oxygen trapped inside a nanobubble is not governed by Henry's Law of oxygen saturation limits.
- Although diffusers are not essential for nanobubbles, it is advisable to use strategically placed discharge lines to promote effective mixing.



An oxygen molecule can theoretically contain about 12,900 oxygen molecules

An oxygen molecule would take roughly 256 days to diffuse 1 foot in water only by Brownian motion.

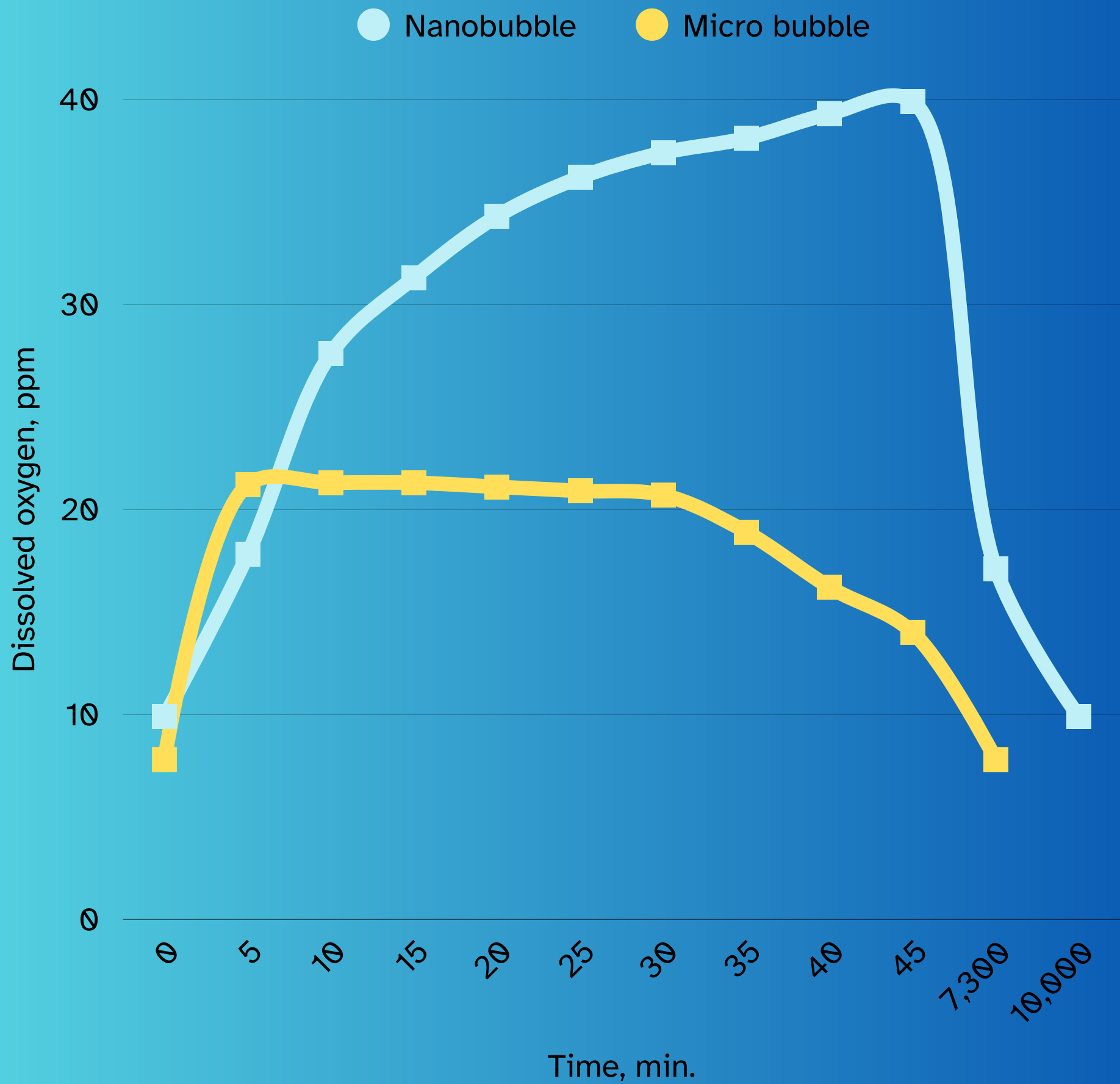
A 100 nm nanobubble would take roughly 336 years to diffuse the same distance only by Brownian motion.

Longevity of nanobubbles

- Extensive research has been conducted on the longevity of nanobubbles in different liquids. One of the notable advantages of nanobubbles is their ability to encapsulate gas and release it through the bubble wall over an extended period of time.
- Traditional aeration methods measure oxygen transfer efficiency (OTR) based on the volume of gas released into a liquid before the bubble surfaces and bursts.
- Nanobubbles are much more effective at discharging the majority of their gas into the liquid before reaching the air/water interface or a solid surface, where they might burst.
- From my personal experience comparing the same volume of oxygen released into nanobubbles versus conventional micro bubble aeration, the results are compelling. Nanobubbles delivered dissolved oxygen (DO) levels that were twice as high as the temperature pressure oxygen saturation values after five days, whereas micro bubbles returned to oxygen saturation levels within just 2.5 days.
- In both cases, the volume of water, temperature, and oxygen source were identical; oxygen levels were monitored, and the same volume of oxygen was transferred to the water. Unsurprisingly, the nanobubble water reached 31 ppm in just 15 minutes, while the fine bubble water achieved only 21 ppm in the same timeframe.

See graph - next page

Comparison of Bubble /DO longevity



Nanobubble oxygenation of soils

- The use of nanobubble air, oxygen, or other gases can have significant effects on soil, influencing its microbiology, chemistry, and physical structure.
- Unlike water, wastewater, or process water, transferring nanobubble oxygen to soil moisture—and subsequently to soil air, plant roots, and soil microorganisms—introduces complexities due to the oxygen consumption of organic and inorganic elements in the liquid.
- Interestingly, if you have sufficiently porous soil that isn't saturated, ambient air can supply enough oxygen for healthy soil and plant growth, provided the root zone is less than 6 to 8 inches deep.
- Research has shown that keeping the root zone and soil microbes consistently supplied with oxygen offers numerous benefits. I will explore this process in greater detail in an upcoming SimpleScience post.
- While Mother Nature graciously provides ambient air at no cost, poorly structured soils that are compacted, waterlogged, or overloaded with excessive organic and inorganic amendments can deplete this oxygen supply. Even the 21% oxygen available can be consumed, leaving the root zone and soil microbes deprived—making a strong case for adding irrigated nanobubble oxygen!

My summary

- Like many emerging technologies, there are numerous quick evaluations regarding their usefulness and advantages. Over the past eight years, I have dedicated my time and energy to gaining a deeper understanding of nanobubble science. My background includes several years of experience in the molecular oxygen transfer process for the environmental remediation sector.
- As I observed the rapid development and expansion of the nanobubble market, I noticed that countless new terms and hypotheses associated with nanobubbles were being promoted as truths, often lacking substantial data or explanations for their validity. There were times when I found myself using nanobubble terminology and conclusions without adequately questioning their accuracy.

While I firmly believe in and promote nanobubble generation equipment, I have also invested significant time in verifying many of the claims and benefits, all without access to a research facility. This led to the creation of **SimpleScience!**

If you have questions or comments regarding any of the information presented let me know. If you have questions about the marketing claims or technology, let me know. Always glad to help!



- Bob@ingenuityworx.com
- +1 207-749-1457