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TECHNOLOGY

2/1/2024

Things We Know About D.O. and Nanobubbles

Chris Beytes

Terminology is important. There are a lot of words used to describe “tiny bubbles” as Sara often refers to them: microbubbles, nanobubbles and ultra-fine bubbles.

“These are all terms that people throw around and use interchangeably,” said Sara. “The only convention for ‘bubble-naming’ comes from Asia, because Japan and Korea and to a certain extent China have done a lot more looking at tiny bubbles and what we can do with them. They established the convention where microbubbles are anything in the micron range; anything smaller than nano-sized is considered an ultra-fine bubble.”

Technically speaking, microbubbles measure anywhere from 1 to 100 microns across (a human hair is about 10 microns). Nano and ultra-fine bubbles (the terms are interchangeable) are from 1 to 100 nanometers (a nanometer is 1 billionth of a meter, or about 1,000 times smaller than a micron).

In the U.S. we tend to hear the term “nanobubble” most often, but that’s more of a commercial or marketing lingo, she said. Just know that nanobubbles and ultra-fine bubbles are the same thing, and are about as small as you can usefully get.

Saturation rate depends on many factors. The amount of D.O. in your water (which is measured in ppm, which equates to milligrams per liter) depends on temperature of the water, altitude of your operation, and even the salinity of your water.

At sea level, at about 68F (20C), a D.O. reading of 9 ppm might be typical. Water that has been treated with nanobubble technology might read 20 or 25 ppm.

However, the warmer the water, the lower its saturation rate—the less D.O. it will hold. Altitude also affects the ability of water to hold D.O., with higher altitudes allowing the bubbles to escape more readily (think about the lower boiling point of water in Denver than in Dallas). Salinity plays a positive role in water’s ability to hold on to nanobubbles, with higher salinity equaling higher saturation rates. Why? “More salt makes your water ‘stickier’ is the best way to look at it,” said Sara.

Nanobubbles can protect plants from salt damage. Researchers have found that you can grow in up to 50% seawater if you add nanobubbles. Why? Sara said the theory is that the bubbles may be covering the surface of the roots, limiting the ion-channel blocking, which is what salt does to the roots. She mentioned a demonstration in Japan where researchers put freshwater and saltwater fish in the same tank and added nanobubbles, and both species thrived.

Another interesting fact about salt: Fruits such as tomatoes and strawberries produced in water with higher salinity are perceived to taste better, with higher sugar content.

You can put more than dissolved oxygen in a nanobubble. Yes, dissolved oxygen is what researchers and the industry have done the most work with, but you can also put dissolved nitrogen or dissolved CO2 in a nanobubble. CO2 can be sequestered in nanobubbles, and it can also be used in the production of microalgae, which can produce sugars, proteins, lipids, pigments and other valuable materials. Ozone in nanobubbles can be used for sanitation. Nitrogen in nanobubbles can also provide a sterilization and antioxidant function in water. Also, because it's fairly neutral, nitrogen can be used to test the effect of nanobubbles on plants without worrying about the gas affecting the plants. In fact, Sara is working on research using nitrogen nanobubbles to learn if it's the bubbles having a positive impact on plant growth, or if it's the dissolved oxygen (she suspected it's a bit of both).

Measure at the root zone, not the tank. After nanobubble treatment, the water in your tank may measure 20 ppm D.O. "Excellent!" you say to yourself. But what is the plant getting? Possibly much less.

Consider an NFT (nutrient film technique) hydroponic greenhouse. Sara explained that by the time that water has navigated all the pipes, valves and many feet of NFT gutter, the plants at the end of the row may only be getting 2 ppm, due to those many obstacles, which can burst the bubbles and cause the D.O. to escape. Plus, plants are pulling oxygen out of the water, so the ones closest to the water source get most of the benefit.

What can you do about that? Flow the water faster, suggested Sara. Or drive your D.O. higher to start with, such as 30 ppm. But she admitted it can be a problem with long gutter systems or high plant density. Drip irrigation systems are less of a problem because the flow through the tubes doesn't tend to affect the D.O. level like the flow in a large gutter.

And don't forget temperature. Your tank might be 65F (18C) and have a good D.O. concentration. But the gutter in the greenhouse might be 78F (26C), so you've lost D.O. just from the temp increase.

Nanobubbles are interesting! "Because they are so small, the pressure of the water pushing down on them is actually greater than the pressure of the gas pushing out," explained Sara. While your typical microbubble is going to pop under pressure, a nanobubble actually shrinks because the water keeps pushing it inward and concentrating the bubble, making it get smaller over time. So eventually, the bubble will completely dissolve or else it will implode, and this implosion will cause the oxygen (or whatever gas you have in there) to get dissolved. Also, it changes the molecules' behavior around them. They tend to have a negative charge on their surface, so they'll attract other molecules to them, which can draw in nutrients.

Nanobubbles boost your root microbiome. You don't think of hydroponic growing systems as having a microbiome. But Sara said anytime you grow anything there's a microbiome in the root system. Her studies in hydroponics have shown that nanobubbles boost the microbiome, giving a greater diversity of bacteria and fungi in the root zone, which increases uptake and assimilation of nutrients, fixes nitrogen, helps convert soluble iron into a form usable by the plant, helps break down the negative chemicals given off by the plant, helps prevent root diseases and more.

Said Sara, "There are some people who are theorizing that some of the benefit that we're seeing in hydroponics is not actually from the interaction between the bubbles and the plant as much as it may be between the bubble and the microbes, in terms of boosting the amount of ‘critters’ in there. We’re still figuring it out, but there’s definitely evidence to suggest that’s what’s going on.”

D.O. and nanobubbles boost yield. While there’s still much research to be done on the biology of how D.O. and bubbles interact with the root zone, there’s no denying the technology cuts crop time and boosts yields. In her research with hydroponic lettuce, normally a 4- to 5-week crop, she was able to reduce the crop time to 2.5 to 3 weeks. That’s a major increase in water-use and space-use efficiency. Other research has shown yield increases of 200% to 300% over untreated crops. The salinity studies show you can grow in lower-quality water, which could be a game-changer for global agriculture.

We know a lot about D.O. and nanobubbles, but there’s still much to learn—which should keep Sara and her colleagues busy for many years to come.

“It’s just an extremely complicated system, as all biology is, and the more you look at it, the more you realize there are more interactions going on in there.”