Ozone Nanobubbles for Larvae Control in Freshwater Canals

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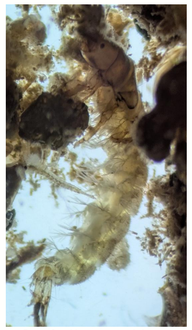
Purpose

Research Question: Are ozone nanobubbles effective at neutralizing caddisfly larvae in natural waters?

My research aims to investigate how ozone nanobubbles can be used to manage nuisance larval populations in their community. Caddisfly larvae could also serve as a model organism for testing this technology, especially problematic species such as mosquitoes that transmit diseases.

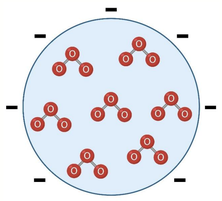
Background



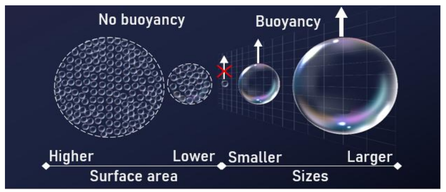
Credit: Kathleen Myers

Smicridea is a genus of caddisflies (order Trichoptera) found in clear, fast-flowing rivers and streams. Their life cycle includes larval, pupal, and adult stages, with larvae thriving in high dissolved oxygen environments like falls. This is relevant to Arizona canal systems, where infrastructure creates oxygen-rich conditions that support large populations. **When populations surge, adult swarms disrupt nearby communities**. One resident described them as “so vast that you just can’t stop it… it’s like walking through a dust storm,” while another said, “we just shut the back door and don’t use the backyard” (Barbara 12 News, 2023).

Nanobubbles (NBs) is a promising method for controlling HABs . NBs are tiny gas spheres about 100 nanometers in diameter. Unlike larger bubbles, they move through Brownian motion, have negligible buoyancy, and remain **stable for hours or days**. This stability enhances gas transfer and persistence in water. When combined with ozone, NBs **increase contact time** and **reduce the ozone dose** required for oxidation. Studies show that ozone NBs can lower the amount of ozone needed for effective contaminant control by roughly 70%, making them an efficient and sustainable water treatment technology.

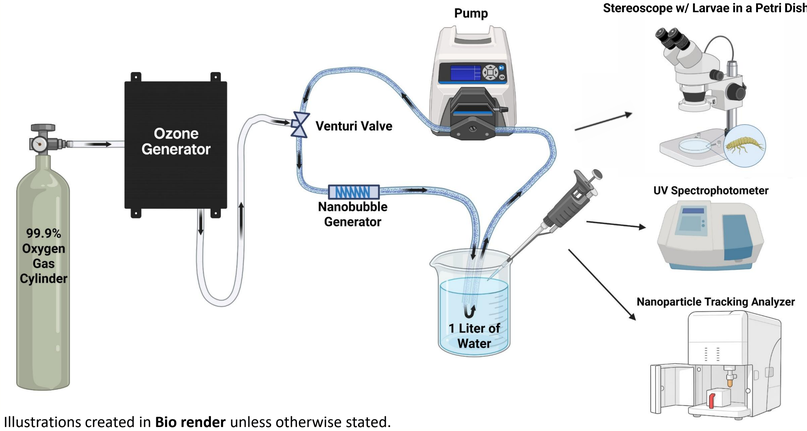


Ozone Nanobubble



Credit: Morón-López, 2023. Journal of plant interactions, 18, 1.

Materials & Methods



Illustrations created in **Bio render** unless otherwise stated.

Apparatus:
Ozone Generator: Converts oxygen gas into ozone gas, which is injected into a venturi valve.
Nanobubble Generator: Static mixer with internal spiral grooves to create NBs through shear force.
Peristaltic Pump: Circulates the water through a closed loop to generate NBs.
UV Spectrophotometer: Determines the ozone concentration by the indigo method.
Nanoparticle Tracking Analyzer: Able to quantify the concentration and size distribution of nanobubbles.

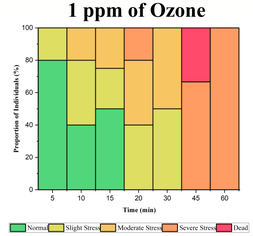
Methods:
Recording videos with a camera attached to a stereoscope for visual identification of and quantitative analysis of larval stress.
Tracking the movement of the larvae (head, thorax, and tail) using a program called ImageJ that can monitor their displacement and velocity.

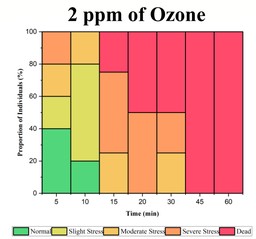
Results & Conclusions

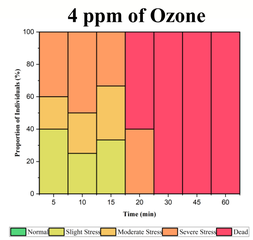
Normal

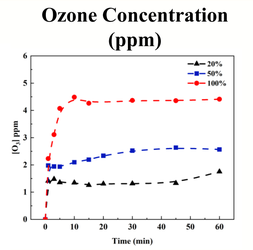
Stressed

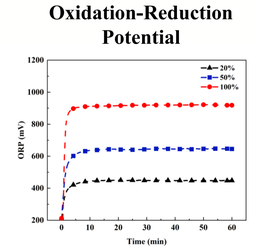
Deceased











There is a clear positive relationship between ozone concentration, exposure time, and larval stress, with stress increasing as concentration rises. This effect is supported by the rapid attainment of maximum ozone concentration, as shown in the figures on the right.

Future Work

The next step is to implement this at the pilot scale in a canal, where an ozone and NB generator is placed in an area known to be prevalent with caddisfly larvae, and to test downstream ozone concentrations and caddisfly viability. Further experiments with other types of larvae, such as mosquito larvae, to test their suitability as model organisms for this treatment, given the limited literature on the matter.

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