NUTS & BOLTS

Ozone for Aquaculture

BY GENNY FRASER

Ozone is a naturally occurring gas. It reacts rapidly with organic materials (about 3,000 times faster than chlorine) and, unlike with chlorine, there are no toxic residues. The reaction by-product of ozone is oxygen, which is usually welcomed in aquaculture systems. Ozone is commonly used in influent water treatment as well as in recirculation systems for two main reasons: disinfection by the killing of harmful pathogens, and improved water quality through enhanced microflocculation. Ozonation is commonly installed immediately prior to protein skimmers, since their efficiency is markedly improved thereby.

Because ozone is such a powerful oxidant, it is important to know what is contained in the water to be ozonated. This is particularly important when sizing ozone generators. Ozone is not selective; it will react with almost anything it contacts including tannins, acids, metals, etc. There are some organic compounds that do not react with ozone and if the reactions are slow, ozone may not be effective. A detailed water analysis should be available to the supplier of the ozone generator, as well as a list of target pathogens. Ozone's can oxidize iron, manganese, sulfides and arsenic, which are commonly found in ground water. These precipitate and can be removed through micro-filtration.

The key benefit of ozone in water treatment is disinfection by removing pathogens. Effectiveness depends on the ozone concentration and the time the ozone is retained in the water i.e. the contact time. There is a wide range of concentration requirements for pathogens found in aquaculture systems. For bacteria and viruses, effective concentrations range from 0.03 to 1 ppm, with retention times from 1 to 10 minutes. Fungi generally require much greater concentrations and contact times for 99% kill rates. Keep in mind, the concentrations and retention times listed for pathogens are for targeting a specified organism; there will be other organics in the water which will also be consuming ozone, so actual concentrations may need to be higher, or contact times longer to ensure efficacy.

PacficOzone 12M24 generator with three way PID control at Marine Harvest Canada's Big Tree Creek Hatchery on Vancouver Island. This generates 720 grams of ozone / hour.with an oxygen feed

Although there are no dangerous by-products from ozone as there are from chemical water treatments, if too much ozone is injected into the source water, there can be a risk of residual ozone getting to the fish, which can be lethal. The gaseous phase of ozone can be hazardous to humans. If you can smell ozone in the air, the concentration is too high (see Nuts and Bolts article of July 2002, Ozone Health and Safety). Isolating the generator is essential, as is installation of a gas phase ozone detector, which will sound an alarm when its set point level is reached.

There are several methods of destroying ozone to ensure that dangerous levels of ozonated water do not reach the fish. A very effective way to destroy ozone in solution before it comes in contact with fish is by ultraviolet light. UV irradiation used in series after the ozone contact system can not only destroy ozone, but is itself a reliable method of disinfection, and can ensure that no harmful pathogens are detected, post-treatment. A combined ozone/UV system is more effective at controlling pathogens than a system using ozone or UV on their own UV, when used to destroy ozone, must be supplied at the correct dosage, which is dependent on ozone concentration and retention time within the UV chamber. Significant work has been done by the Freshwater Institute at Shepherdstown WV, to determine which dosages work best. There are many variables that have to be considered before a UV unit could be sized properly for ozone destruction.

Because ozone cannot be stored, it must be generated on-site and used immediately, and there are several different types of ozone generators suitable for aquaculture available on the market. Ozone for water treatment may be generated in two ways: Ultraviolet ozone generation and corona discharge generation. Ultraviolet ozone generation is accomplished by passing air or oxygen past an ultraviolet lamp producing UV light at the specific frequency of 185 nm. Ironically, ultraviolet light can produce ozone, but at the longer wavelength of 254 nm it will also destroy ozone. The other way of producing ozone is by corona discharge, which operates by passing dry air or oxygen through a high-energy electrical field (diffused over a dielectric surface). Both methods work by splitting the oxygen molecule O_2 into atoms, which then reattach to make O_3.

A small ozone contact system with a generator and contact tank.

Ozone generators operate best when fed with about 95% pure oxygen. Oxygen produced by an on-site oxygen generator is the best quality for efficient ozone production. Bulk oxygen trucked in by a supplier is about 99% pure which is not ideal for ozone generation. The oxygen supplier should be able to supply a nitrogen injection kit, which would inject about 3% nitrogen to the oxygen making a perfect mix for ozone generation. Ozone generators can also be supplied with air (although a natural air feed is about 3 times less efficient than oxygen).

The corona discharge style of generation, the type most frequently used in aquaculture, uses 85-95% of the energy consumed to produce heat. Therefore the units must be cooled. A good cooling system will increase the efficiency of the unit. Either air or water can be used for cooling. Water-cooled units (e.g. Ozonia) need a clean, chilled water source flowing steadily through the generator. These units come in a wide range of ozone production capacities. Some are quite small, while other units are large enough to use in the biggest municipal drinking water treatment plants treating hundreds of litres per second. Air-cooled units (e.g. Pacific Ozone) require a steady flow of cool, dry air through the generator to the exhaust. The purchaser's choice will depend on site conditions, installation requirements and available utilities.

Inclusion of ozone in an influent water treatment train can aid in the overall quality of hatchery supply water by enhancing clarity through micro-flocculation and also as an effective disinfectant. Ozone can reduce some of the worries associated with poor water quality and thereby increase overall hatchery productivity.

Genny Fraser, Mech. Eng. is a technologist with PRAqua Technologies of Nanaimo BC. For more information contact her at: genny@praqua.com, or by phone at: +1 250 714 0141