APPLICATION NOTE A2.1:
Prevention of Gas Bubble Disease in Fish

Introduction

Ensuring the health of fish in both natural and aquaculture settings requires careful monitoring of water quality parameters. Without monitoring and control of these parameters, poor health and even death are serious risks.

Temperature, O_2, pH, ammonia, and nutrient levels are commonly monitored and controlled, when possible, in open pen, open tank, and closed loop aquaculture systems. These parameters are chosen for their ease of measurement, low cost, and importance to fish health. However, in certain applications, monitoring TDGP (total dissolved gas pressure) is important for the prevention of gas bubble disease in fish.

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Causes of Gas Supersaturation

- Leaks on the suction side of water pumps will entrain ambient air into the system. This air dissolves into the higher-pressure water and is transferred to fish holding tanks through the water pump discharge.
- High dissolved gas levels in source-water being pumped into aquaculture systems.
- Supersaturation in rivers can result from air injected as bubbles from hydroelectric dams, spillways, and waterfalls.
- Over-injection in oxygenation systems.
- Rapid changes in temperature

Figure 1. Zebrafish with GBD. Note the gas bubbles formed above the eyes under the outer tissue layer. Image from: http://zebrafish.org/health

Effects on Fish

Gas bubble disease (GBD) occurs when fish are exposed to dissolved gas levels that are above the maximum stable gas concentration for the local temperature, salinity, and pressure conditions (i.e. gas supersaturation). Water that is supersaturated with dissolved gas can result in the generation of free gas bubbles. Bubbles (emboli) form in the vascular system and other tissues of fish. Cranial swelling and bulging of the eye can also occur. Larvae and fry exhibit hyperinflation of the swim bladder and eggs float to the surface.

Mortality can reach 50 - 100 % due to acute gas bubble trauma. In shallow aquaculture ponds, fish cannot escape to deeper waters where gas supersaturation is less likely to occur. The onset of GBD is rapid and requires a fast-response instrument for monitoring that is also reliable and accurate.

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Measurement of TDG Pressure

Total dissolved gas pressure (TDGP) is measured through equilibrating a gas headspace with surrounding water. A semi-permeable membrane facilitates this process and a pressure sensor measures the sum of the partial pressures of all gases dissolved in the water:

$TDGP = pN_2 + pO_2 + pCO_2 + pH_2O + pAr + ...$

These 5 gases make up more than 99.5% of dissolved gases in nearly all natural waters. TDGP can also be compared to barometric pressure, P_{baro}, and percent saturation determined:

$\%\ Saturation = TDGP / P_{baro} \times 100\%$

Dissolved gas pressure can also be expressed as a differential pressure, ΔP,

$\Delta P = TDGP - P_{baro}$

The gas pressure that affects fish and dictates whether GBD can occur is the pressure differential between the TDGP and the sum of hydrostatic (P_{hydro}) and barometric (P_{baro}) pressures. When $TDGP > P_{baro} + P_{hydro}$ gas, dissolved in the water will form free gas bubbles. The formation of these gas bubbles results in GBD. The water depth where $TDGP = P_{baro} + P_{hydro}$ is called the compensation depth.

When fish swim from below the compensation depth to shallower waters above the compensation depth, dissolved gas pressure becomes greater than the pressures in body fluids confining the gas in solution, and this can lead to gas bubble formation on tissues in fish.

Pro-Oceanus
Solu-Blu TDG Sensor

TDG Sensors

Pro-Oceanus manufactures several models of TDG sensors to suit any application where dissolved gases may be a problem. The Solu-Blu TDG sensor can be incorporated into many water recirculation systems with ease. It provides both barometric and TDG pressure measurement in a single sensor, providing long-term % Saturation monitoring.

Unlike traditional TDG sensors that use silicone microbore tubing that is easily fouled and may slowly leak water over time, the Pro-Oceanus TDG sensors utilize an advanced flat membrane material that eliminates these problems. This results in better long term accuracy, reliability, and lower cost of ownership.

Having a rapid response sensor that can trigger an alarm to shut down a faulty circulation pump before a threshold TDGP occurs is the only effective means of preventing GBD due to air entrainment by a circulation pump in aquaculture systems.

Pro-Oceanus produces total dissolved gas sensors for measurement of dissolved gas pressure and saturation level. Both standalone and easily integrated probes are available. The engineering and science teams at Pro-Oceanus can provide customized solutions to fit virtually any need.

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