CARBON DIOXIDE AS LIMITING FACTOR IN PARTIAL REUSE SYSTEMS

Asbjørn Bergheim[1], Torbjørn Øvrebotten[2], Sveinung Fivelstad[3] and Yngve Ulgenes[4]

1) IRIS – Int. Res. Inst. Stavanger, Stavanger, Norway; 2) Firda Seafood, avd. Botnane, Norway; 3) Bergen Univ. College, Bergen, Norway;
4) BioFarmSystems as, Trondheim, Norway

Abstract

About two-thirds of the Norwegian production of smolt (more than 200 million) takes place in intensified flow-through systems applied tank-internal removal of accumulated carbon dioxide (CO_2). Elevated CO_2 concentration in the tanks at high water temperature and peak biomass before smolt delivery is a potential risk for the fish's health and welfare.
In general, the ongoing intensification of the systems ('partial-RAS'), characterized by high fish density and low specific water flow, makes high demand of the reliability and efficiency of the employed technology for CO_2 removal. Available CO_2 figures from commercial farms are sparse, but measured peak concentrations above 30 – 40 mg/L in smolt tanks have been reported. As a general guideline, the CO_2 concentration in freshwater tanks stocked with salmon and trout should not exceed 15 mg/L throughout the production cycle.
Newly developed systems demonstrate improved CO_2 removal compared to commonly applied systems. A removal rate of 60 – 75% is currently measured in a pilot aerator at an air: water ratio of 10:1 even at quite low CO_2 levels (ca. 10 mg/L). Moreover, the system is combining CO_2 removal and back-flushing of the aerator's media for fouling control. Fouling and reduced CO_2 removal efficiency have been major and recurring problems in commonly applied aerators.
A recent study indicates that tanks stocked juvenile rainbow trout at temperature above 10 °C should be equipped up-to-date aeration systems for reliable CO_2 control at flow rates below 0.2 – 0.3 L/kg/min.

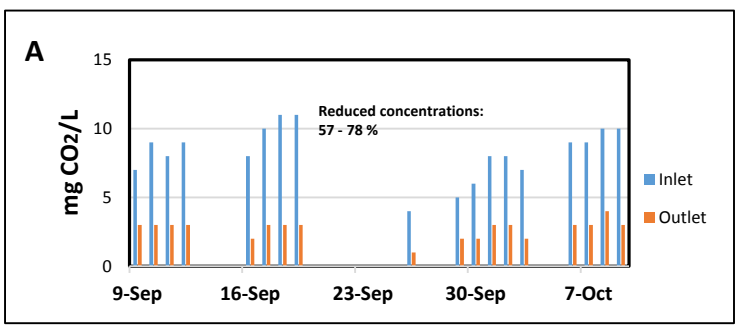
Figure 1.

Over: The GasBuste® aerator for aeration of 10 m3/minute, connected to two Ø14 m fish tanks.

Right: Aeration media (VFF Netball 45-P) used for 4 months at 14 – 16 ºC. As can be seen there is no biofilm or particles attached to the media balls - documening the efficiency of cleaning of the system.

A recently designed system

Commonly applied aerators in fish tanks typically remove about 50% of CO_2 at moderate CO_2 concentrations. Reduced removal effect due to fouling is a well-known problem, especially during summer – autumn at high temperature, peak biomass and feed supply. Lacking efficiency of the aerators thus limits the annual production volume and the fish's welfare. The presented system, GasBuster® marketed by Alvestad Marin AS Norway (www.alvestad.com), is designed to diminish fouling problems and optimize the operational standard of aerators in a cost-effective way. GasBuster® is built as a trickling column filled with aeration media (i.e. VFF NetBall, http://www.vff.com/en/products/random-packings/plastics). Water is evenly distributed by perforated plate on top of the aerator and trickles down through the aeration media where the water is splitted for making a large surface area to air. Mounted on top of the aerator is a low pressure fan for blowing air upwards through the aeration chamber making counter current aeration which is the most efficient aeration principle for aquaculture. Ratio air:water is normally 10:1 but might vary. The aeration media is washed every day automatically in a process taking approximately 15 minutes. During washing the aeration column is filled with water and the aeration media is rinsed by high pressure nozzles making a circular movement in the aeration bed. During the washing cycle air flow is stopped but water flow through the unit is constant.
Experience from more than 2 years continuous operation shows that the aeration media is kept clean all the time (Figure1). Clean aeration media is the most important assumption for stable and highly efficient CO_2 removal in the GasBuster aeration concept.



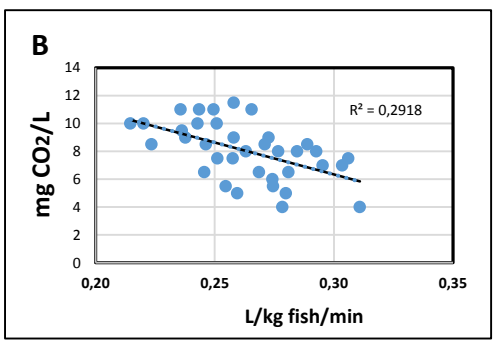


Figure 2.

A: Concentration of CO_2 in/out of the aerator (mg/L).
B: Concentration of CO_2 in fish tank water (mg/L) vs. specific water consumption rate.

Aerator tests

Autumn 2014, a newly installed GasBuster® unit was tested at a commercial smolt producing farm. The Aerator was run at an air : water ratio of ca. 10:1 at full hydraulic capacity (10,000 L/min) operating two tanks of 470 m^3/tank stocked with trout of 50 – 70 g. Monitoring over one month (Figure 2) demonstrated 57 – 78% reduced CO_2 concentration through the aerator at low – moderate inlet concentrations (4 – 11 mg/L). The daily backwashing of the media seemed to fully maintain the stripping effect. Use of the Aerator allows a specific water flow of 0.20 – 0.25 L/kg fish/min in rainbow trout fingerling tanks at summer temperature. Under similar conditions, the formerly applied aerator system at the farm resulted in CO_2 concentrations of > 25 mg/L.