Start-up performance of a woodchip bioreactor operated end-of-pipe at a commercial fish farm—A case study - DTU Orbit (10/11/2019)

Start-up performance of a woodchip bioreactor operated end-of-pipe at a commercial fish farm—A case study

There is a need for simple, maintenance-free technologies for removing nitrogen (N) from aquaculture effluents. Denitrifying woodchip bioreactors have been used successfully to remove nitrate-N (NO$_3$-N) from ground and surface waters and may potentially be applied to dilute aquaculture effluents as well. Real-life applicability in commercial, outdoor fish farms including practical start-up issues such as e.g. time till stable performance and potential leaching are, however, unknown to the industry. This case study consequently investigated the temporal performance of a woodchip bioreactor (12.5 m$^3$) during start-up. The bioreactor was operated end-of-pipe at a commercial, outdoor rainbow trout (Oncorhynchus mykiss) farm in Denmark operated at low recirculation intensity. Applying an empty bed contact time (EBCT) of 5 h, the specific objectives of the study were to resolve: i) how fast the bioreactor would start to remove NO$_3$-N; ii) how fast steady state was achieved; iii) which NO$_3$-N removal rates could be attained at the relatively low effluent temperature (∼8 °C) and iv) to which extent any concomitant leaching of phosphorous (P), ammonia or organic matter would occur. In- and outlet grab samples were obtained every 6 h until the bioreactor was in steady state (2 weeks) followed by weekly 24 h pooled samples for another 3 weeks (5 weeks in total). Additional grab samples were obtained from 9 sampling ports within the bioreactor on 3 consecutive days during steady state. Samples were analyzed for dissolved nutrients (total N, nitrate, nitrite, ammonium, total phosphorous, ortho-phosphorous, BOD5 and COD). In addition, oxygen, temperature and pH were logged every 30 min while sampling and alkalinity were measured once a week. Removal of NO$_3$-N started immediately and remained stable at 7.06 ± 0.81 g NO$_3$-N/m$^3$/d ($n = 6$) throughout the sampling period. Increased effluent NO$_2$-N concentrations (peaking at 1.14 mg NO$_2$-N/l after 4–5 days) were transiently observed during the initial 11 days. After that, the woodchip bioreactor was largely in steady state with respect to N-balances corroborated by a close match between filtered total-N (TN$_{diss}$) and NO$_3$-N removal rates. Measurements within the bed showed that the majority of the influent dissolved oxygen (DO) was consumed within the first part of the bioreactor and that NO$_3$-N removal thereafter proceeded gradually with distance within the bed. Leaching of non-structural, dissolved organic compounds were observed just after startup, causing a short-term (1 week) increase in effluent concentrations of COD, BOD5, P and ammonium. Additional measurements carried out until 147 days after start-up showed that the woodchip bioreactor continued to remove TN$_{diss}$ at an average removal rate of 7.81 ± 0.82 g N/m$^3$/d, and that the initial leakage of P stopped altogether. In summary, the study demonstrated that woodchip bioreactors can effectively remove NO$_3$-N from dilute aquacultural effluents at low temperatures and commercial conditions and that stable performance is achieved within a few weeks.

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