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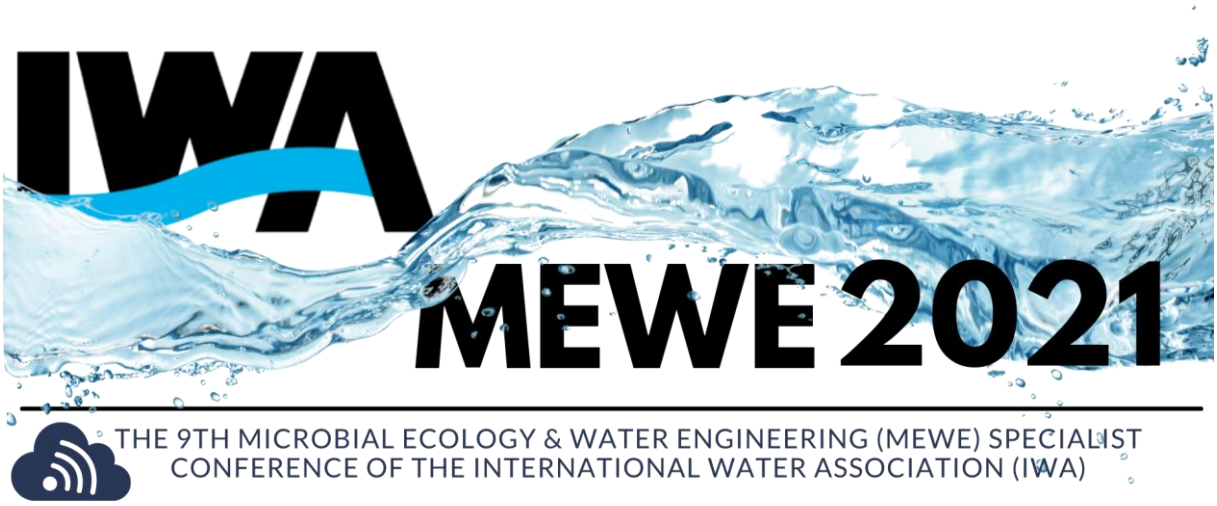

High rate denitrification as an alternative process for energy and nutrient recovery

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High rate activated sludge (HRAS) systems, which are aerobic, are used for redirecting organics for energy recovery. The HRAS works at low sludge retention time (SRT), very short hydraulic retention time (HRT) and a high food to microorganism ratio (F/M). Effluents from these systems have a low carbon level which makes them suitable for partial nitritation anammox (PN/A) treatment. However, unsuccessful nitrite oxidizing bacteria suppression and low ammonia concentrations prevent the implementation of mainstream PN/A in cold climates. Thus, a high-rate denitrification system is proposed as an alternative for simultaneous carbon recovery and nitrate removal as an A-stage, where the B-stage would be a nitrifying reactor whose clarified effluent is recycled to the A-stage for denitrification (i.e., mimicking pre-denitrification/nitrification). This study focuses on the A-stage, evaluating process stability at low SRTs, relating settleabilty to floc morphology and assessing the energy and nutrient recovery potential as biogas and microbial protein, respectively.

Denitrification rates ranged between 0.77-1.33 g-NO_3-N/g-TSS/d, higher than reported for the pre-anoxic zones for domestic wastewater (0.04-0.25 gNO3-N/g-VSS/d). Phosphate removal averaged around 50%. Sludge volume index (SVI_{30}) was below 50 ml/g, which is lower than for aerobic HRAS systems (typically ranging 50-300 ml/g), suggesting good sludge settling characteristics. Decreasing SRTs led to decreasing floc size, without compromising sludge sedimentation. The sludge yield ranged between 0.41-0.67 g-TSS/g-COD, similar to aerobic HRAS. Highest biomethane yield, 686 ± 82 ml-CH_4/g-VS, was observed at SRT 3 days, which is considerably higher than yields for secondary sludge. Protein content was highest at the lowest SRT, 26.8% of dry weight, in the range observed for the aerobic HRAS. Protein contained all amino acids, although their balance was far from those of fish meal or soymeal

proteins. Given the low protein yield and the poor amino acid balance, biogas production seems a better option for sludge valorization.

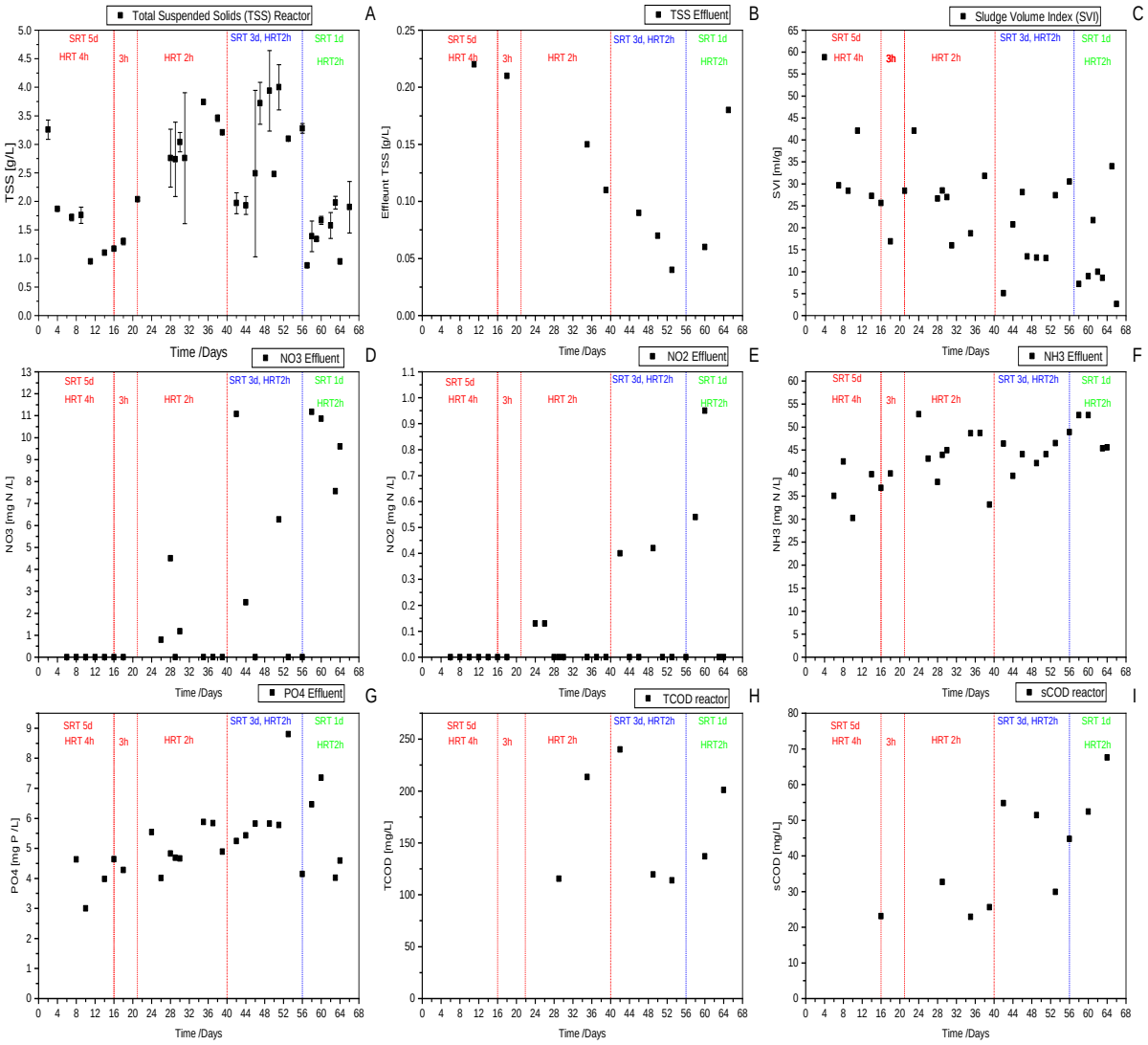

Figure 1: Performance of the high rate denitrifying activate sludge process: a) total suspended solids in the reactor (g/L); b) total suspended solids in the effluent (g/L); c) sludge volume index (ml/g); d) nitrate (mg-N/L); e) nitrite (mg-N/L); ammonia (mg-N/L); g) phosphate (mg-P/L); h) total chemical oxygen demand in the effluent (mg-COD/L); I) soluble chemical oxygen demand in the effluent (mg-COD/L). The system was operated at three solid retention times (5, 3 and 1 days). The hydraulic residence time was adapted during the first period, at SRT 5 days, decreasing it from 4 to 2 h.