Simultaneous phosphorus uptake and denitrification by EBPR-r biofilm under aerobic conditions: effect of dissolved oxygen

RATE CALCULATIONS

Table 1, Table 2, Figure 2(a), 2(b), 2(e) and 2(f):
P uptake rate (PUR), NOx removal rate and oxygen uptake rate (OUR) were calculated from the steepest part of the kinetic profile of Figure S5, and are expressed in either mg/L*h or mmol/g TS*h:

\[
\text{PUR} = \frac{\text{NOx removal rate (mmol/gTS* h)}}{\text{Maximum rate of kinetic profile (mmol/L* h)}} \times \text{Volume of solution (2.4 L)} \times \text{Total biomass (g)}
\]

\[
\text{OUR (mmol/gTS* h) in the column reactor = } \frac{(\text{Influent DO - Effluent DO})(\text{mmol/L}) \times \text{Volume of solution (0.36 L)}}{\text{HRT in column reactor (0.0459 h)} \times \text{Total biomass (g)}}
\]

Figure 2(c) and 2(g):
The electron accepting rate for O2 and NO3 reductions were calculated according to the equation below:

\[
\text{Reduction rate of O}_2 \quad (\text{mmol e}^-/\text{gTS* h}) = \frac{\text{OUR} \times 4e^-}{\text{Reduction rate of O}_2 + \text{Reduction rate of NO}_3} \times 100
\]

% of electrons for PHA oxidation with O2 reduction

\[
= \frac{\text{Reduction rate of O}_2}{\text{Reduction rate of O}_2 + \text{Reduction rate of NO}_3} \times 100
\]

- It was assumed that the reduction of a mole of O2 to H2O consumes 4 moles of electrons. The OURs were recorded as the average value of the steepest part of the OUR profile in Figure S3(d) and (h) of the supporting information.

- It was assumed that the reduction of a mole NO3 to NO2 consumes 2 moles of electrons, and that the reduction of a mole of NO3 to nitrogen gas consumed 5 moles of electrons. The net NO3 removed (the total NO3 removed minus NO2 formed) was the net NO3 removed in the system to form nitrogen gaseous products.

Figure 2(d) and 2(h):
The percentage of electrons used for P uptake with O2 and NO3 as electron acceptors was calculated as follows:

% of electrons for PHA oxidation with NO3 reduction

\[
= \frac{\text{Reduction rate of NO}_3}{\text{Reduction rate of O}_2 + \text{Reduction rate of NO}_3} \times 100
\]

- It was assumed that all electrons consumed in the system through the reduction of O2 and NO3 were used for PHA oxidation.
During the initial feeding period (20 min) of the P-uptake phase, the concentrated stock solution (0.48 L) was diluted with DI water (6.72 L) to provide a wastewater stream containing low P and N concentrations (7.2 L). This stream was continuously recirculated into the master reactor to facilitate P uptake for 210 min. At the end of this phase, the wastewater stream was decanted completely (10 min) from the master reactor. During the subsequent P-release phase, the recovery stream (consisting of 0.12 L of concentrated stock solution and 1.68 L DI water) was introduced (5 min) and recirculated for 105 min to facilitate P release via acetate uptake. At the end of this phase, the recovery stream containing enriched P was decanted (10 min) and harvested from the master reactor.

Concentrations of soluble (a) PO₄³⁻-P, (b) NOₓ-N (NO₃⁻/NO₂⁻), and (c) NO₂⁻-N associated with the enriched biofilm over time under three electron acceptor scenarios: (1) O₂ alone (8 mg/L of bulk DO); (2) NO₃⁻ alone (10 mg-N/L); and (3) O₂ and NO₂⁻ in combination.
Figure S3 | The concentrations of soluble (a) and (e) PO$_4$$^{3-}$-P, (b) and (f) NO$_3^-$-N (NO$_3^-$-N + NO$_2^-$-N), (c) and (g) NO$_2^-$-N, and (d) and (h) the oxygen uptake rate (OUR) for the EBPR-r biofilm in two sets of batch experiments: (1) varying bulk DO concentrations (0–8 mg/L) at an initial NO$_3^-$-N concentration of 10 mg-N/L; and (2) varying initial NO$_3^-$-N concentrations (0–50 mg-N/L) at a constant bulk DO concentration of 8 mg/L.