Influence of operating parameters on the performance of a continuously aerated SHARON reactor

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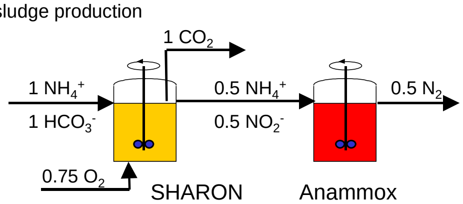
Introduction

The SHARON-Anammox process

The combined SHARON-Anammox process is a promising process for biological nitrogen removal from ammonium-rich wastewater (~1gNH_4-N/l).

Advantages compared to conventional nitrification-denitrification:
- savings on aeration energy (63%)
- no need for carbon source addition
- low sludge production



The optimal nitrite/ammonium ratio (1/1 in theory) in the Anammox influent should be produced by the SHARON process.

The SHARON process

- completely stirred tank reactor (CSTR)
- high temperature (~35°C)
- short retention time (~1day)

$\Rightarrow NH_4^+ \rightarrow NO_2^- \nrightarrow NO_3^-$

- protons produced during nitrification are neutralized through CO_2 stripping

In theory:

IF $\left(\frac{HCO_3^-}{NH_4^+}\right)_{influent} = \frac{1}{1}$ THEN $\left(\frac{NO_2^-}{NH_4^+}\right)_{produced} = \frac{1}{1}$

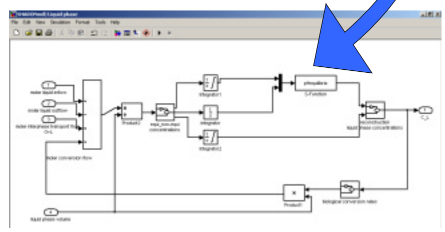
In practice:

The produced nitrite/ammonium ratio is influenced by a number of factors.

The SHARON model

Implemented in Matlab 6.1-Simulink 4.1

Consists of
- 16 liquid phase mass balances
- 5 biological conversion processes in liquid phase
- 3 gas phase mass balances
- diffusion processes between gas and liquid phase



pH effects are very important ⇒
chemical equilibria are considered & lumped components are defined:

$H_2O \leftrightarrow H^+ + OH^-$

$NH_4^+ \leftrightarrow NH_3 + H^+$ TNH = $NH_4^+ + NH_3$

$HNO_2 \leftrightarrow H^+ + NO_2^-$ TNO2 = $HNO_2 + NO_2^-$

$CO_2 + H_2O \leftrightarrow H^+ + HCO_3^-$

$HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$ TIC = $CO_2 + HCO_3^- + CO_3^{2-}$

assume steady state

From the charge balance in the reactor:

$- H^+ + OH^- - NH_4^+ + NO_2^- + NO_3^- + HCO_3^- + 2\,CO_3^{2-} - Z^+ = 0$

the pH and corresponding equilibrium concentrations are calculated.

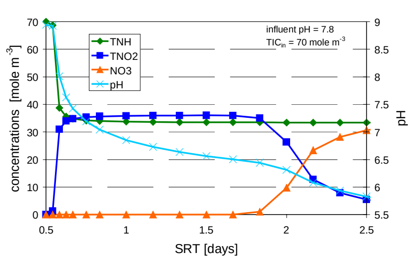
Objective

Perform a simulation study to examine the influence of operating parameters on the nitrite/ammonium ratio produced by the continuously aerated SHARON process

Simulation results

Steady state simulation results for the behaviour of the continuously aerated SHARON system are presented (influent TNH = 70 mole m^{-3}).

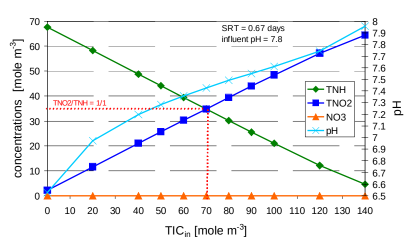
Influence of the sludge retention time



0.65 d^{-1} < SRT< 1.6 d^{-1} to establish partial nitrification

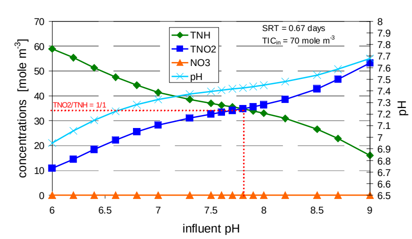
resulting $\frac{TNO_2}{TNH}$ is hardly influenced in this operating region

Influence of the influent TIC concentration



influent TIC ↗ ⇒ HCO_3^- ↗ ⇒ buffer capacity ↗ ⇒ $\frac{TNO_2}{TNH}$ ↗

Influence of the influent pH



influent pH ↗ ⇒ $\frac{HCO_3^-}{TIC}$ ↗ ⇒ buffer capacity ↗ ⇒ $\frac{TNO_2}{TNH}$ ↗

Conclusions

The $\frac{TNO_2}{TNH}$ ratio produced by the SHARON process hardly varies with varying SRT, but is highly influenced by the buffer capacity of the influent, that varies with influent pH and TIC concentration.

TAKE HOME MESSAGE

- For efficient realization of the combined SHARON-Anammox system, it is crucial to control the $\frac{TNO_2}{TNH}$ ratio produced by the SHARON process
- Operating parameters influencing the buffer capacity of the SHARON system are suitable control handles

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