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Process Performance and Nitrogen Removal Kinetics in Anammox Hybrid Reactor

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Abstract : Anammox is a promising and cost effective alternative to conventional treatment systems that facilitates direct oxidation of ammonium nitrogen under anaerobic conditions with nitrite as an electron acceptor without addition of any external carbon sources. The present study investigates the process kinetics of laboratory scale anammox hybrid reactor (AHR) which combines the dual advantages of attached and suspended growth. The performance & behaviour of AHR was studied under varying hydraulic retention time (HRTs) and nitrogen loading rate (NLRs). The experimental unit consisted of 4 numbers of 5L capacity anammox hybrid reactor inoculated with mixed seed culture containing anoxic and activated sludge. Pseudo steady state (PSS) ammonium and nitrite removal efficiencies of 90.6% and 95.6%, respectively, were achieved during acclimation phase. After establishment of PSS, the performance of AHR was monitored at seven different HRTs of 3.0, 2.5, 2.0, 1.5, 1.0, 0.5 and 0.25 d with increasing NLR from 0.4 to 4.8 kg N/m3d. The results showed that with increase in NLR and decrease in HRT (3.0 to 0.25 d), AHR registered appreciable decline in nitrogen removal efficiency from 92.9% to 67.4 %, respectively. The HRT of 2.0 d was considered optimal to achieve substantial nitrogen removal of 89%, because on further decrease in HRT below 1.5 days, remarkable decline in the values of nitrogen removal efficiency were observed. Analysis of data indicated that attached growth system contributes an additional 15.4 % ammonium removal and reduced the sludge washout rate (additional 29% reduction). This enhanced performance may be attributed to 25% increase in sludge retention time due to the attached growth media. Three kinetic models, namely, first order, Monod and Modified Stover-Kincannon model were applied to assess the substrate removal kinetics of nitrogen removal in AHR. Validation of the models were carried out by comparing experimental set of data with the predicted values obtained from the respective models. For substrate removal kinetics, model validation revealed that Modified Stover-Kincannon is most precise (R2=0.943) and can be suitably applied to predict the kinetics of nitrogen removal in AHR. Lawrence and McCarty model described the kinetics of bacterial growth. The predicted value of yield coefficient and decay constant were in line with the experimentally observed values.

Keywords : anammox, kinetics, modelling, nitrogen removal, sludge wash out rate, AHR
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