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Investigating the Process Kinetics and Nitrogen Gas Production in Anammox Hybrid Reactor with Special Emphasis on the Role of Filter Media

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Abstract : Anammox is a novel and promising technology that has changed the traditional concept of biological nitrogen removal. The process facilitates direct oxidation of ammonical nitrogen under anaerobic conditions with nitrite as an electron acceptor without the addition of external carbon sources. The present study investigated the feasibility of anammox hybrid reactor (AHR) combining the dual advantages of suspended and attached growth media for biodegradation of ammonical nitrogen in wastewater. The experimental unit consisted of 4 nos. of 5L capacity AHR inoculated with mixed seed culture containing anoxic and activated sludge (1:1). The process was established by feeding the reactors with synthetic wastewater containing NH4-H and NO2-N in the ratio 1:1 at HRT (hydraulic retention time) of 1 day. The reactors were gradually acclimated to higher ammonium concentration till it attained pseudo steady state removal at a total nitrogen concentration of 1200 mg/l. During this period, the performance of the AHR was monitored at twelve different HRTs varying from 0.25-3.0 d with increasing NLR from 0.4 to 4.8 kg N/m3d. AHR demonstrated significantly higher nitrogen removal (95.1%) at optimal HRT of 1 day. Filter media in AHR contributed an additional 27.2% ammonium removal in addition to 72% reduction in the sludge washout rate. This may be attributed to the functional mechanism of filter media which acts as a mechanical sieve and reduces the sludge washout rate many folds. This enhances the biomass retention capacity of the reactor by 25%, which is the key parameter for successful operation of high rate bioreactors. The effluent nitrate concentration, which is one of the bottlenecks of anammox process was also minimised significantly (42.3-52.3 mg/L). Process kinetics was evaluated using first order and Grau-second order models. The first-order substrate removal rate constant was found as 13.0 d-1. Model validation revealed that Grau second order model was more precise and predicted effluent nitrogen concentration with least error (1.84±10%). A new mathematical model based on mass balance was developed to predict N2 gas in AHR. The mass balance model derived from total nitrogen dictated significantly higher correlation (R2=0.986) and predicted N2 gas with least error of precision (0.12±8.49%). SEM study of biomass indicated the presence of the heterogeneous population of cocci and rod shaped bacteria of average diameter varying from 1.2-1.5 mm. Owing to enhanced NRE coupled with meagre production of effluent nitrate and its ability to retain high biomass, AHR proved to be the most competitive reactor configuration for dealing with nitrogen laden wastewater.

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