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Effects of biofilm geometry on deammonification biofilm performance: A simulation study

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ABSTRACT

Three geometrically different biofilms were investigated for the start-up of deammonification reactor. The planar biofilm with 4 g/L biomass could achieve 0.47 kgN/(m^3 day) nitrogen removal, compared to only 3 and 2 g/L biomass needed for cylindrical and granular biofilms, respectively. Planar biofilm was significantly affected by Dissolved Oxygen (DO) changes, whereas granular biofilm could effectively work in a wide range of DO. The maximum performance of 0.49, 0.83 and 1.27 kgN/(m^3 day) were obtained in planar, cylindrical and granular biofilms, respectively, reflecting that granular biofilm was the most capable due to its large surface area for mass transfer. Cylindrical biofilm was also effective as denitrifiers growth was intimately related to a large anaerobic zone. In addition, DO should be increased abruptly for each biofilm as the shortened HRT. This investigation indicates profound influence of biofilm geometry on deammonification process, which might serve as input for further experimental progress.

1. Introduction

Deammonification has received much attention within the fast emerging field of nitrogen removal in the 1990s (Mulder et al., 1995). It is especially used for the treatment of sludge digester supernatant, high-strength reject water, landfill leachate and animal wastewater (Hippen et al., 1997; Lieu et al., 2005). In this process, anaerobic ammonium oxidation, nitrification and minor denitrification occur in a single-reactor, with low operational cost to achieve high C and N removal efficiencies. To date, Rotating Biological Contactor (RBC) (Windey et al., 2005), Fixed-Bed Reactor (FBR) (Furukawa et al., 2006), Moving Bed Biological Reactor (MBBR) (Seyfried et al., 2001; Rosenwinkel and Cornelius, 2005; Plaza et al., 2003), Sequencing Batch Reactor (SBR) (Wett, 2006; Innerebner et al., 2007; Joss et al., 2009) and Air Lifted Reactor (ALR) (Sliekers et al., 2003; Vázquez-Padín et al., 2009) have been applied to run the deammonification process and several units have been built up for the industrial wastewater treatment (Wett, 2006; Waki et al., 2007; van der Star et al., 2007; Joss et al., 2009). Recently, the anammox-related technology was successfully applied in the sewage treatment, which opens real perspectives for a complete redesign of the energy-consuming into an energy-yielding wastewater treatment (Kartal et al., 2010; Ma et al., 2011).

In these reactors, nearly all of the biomass existed in the form of biofilm with different geometries-planar biofilm (RBC and FBR), cylindrical biofilm (MBBR) and granular biofilm (SBR and ALR). The formation of the biofilm provides a way to obtain good biomass retention and stratified biofilm structure (Masłoń and Tomaszek, 2007). Along the biofilm depth, oxygen diffusion limitation creates the existence of aerobic and anoxic microenvironments.

Despite long standing interests in biofilm, there was little systematic data (both experimental and theoretical) that examines the influence of geometry on the biofilm performance. The availability of such data is critical for confirming the biofilm surface area, aerobic and anaerobic zones and microbial spatial distribution. Moreover, although in the current deammonification researches (Brockmann et al., 2006; Park et al., 2010; Jaroszynski et al., 2011), the start-up of some reactors has been successfully achieved by using many control methods and strategies, the effects of biofilm geometry on its performance, remains to be demonstrated.

In this study, three geometrically different biofilms, i.e. planar, cylindrical and granular were accommodated in a biofilm model within the tool AQUASIM (Reichert, 1998). The simulated results show that biofilm geometry can lead to distinct reactor performance. The systematic comparison could also allow the development of suitable strategies and rational design approaches to enhance the deammonification performance.

2. Model description

All reactors were composed of two successive compartments: a completely mixed biofilm compartment with bulk volume of

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