

Estimation of nitrification capacity of rock media trickling filters in external nitrification BNR

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Abstract

In the external nitrification (EN) biological nutrient removal (BNR) activated sludge (AS) system, the nitrification process is removed from the BNR activated sludge system and performed 'externally' on an integrated nitrifying trickling filter (NTF). As such, optimum design and operation of the NTF is essential for reliable performance of the ENBNRAS system. Although information on the design and operation of NTFs is available in the literature, this experience is not directly applicable to the NTF in the ENBNRAS system. To address this deficiency, a full-scale ENBNRAS prototype was implemented at the Daspoort Wastewater Treatment Works (DWWTW) in Tshwane, South Africa. In this investigation an average apparent nitrification capacity of approximately 1.25 to 1.29 gN per m² of media surface area per day [gN/(m²·d)] ammonia removal was determined for 2 existing rock media TFs retrofitted as NTFs in the prototype ENBNRAS system (nominal surface area of 45 m²/m³ for the rock media). This nitrification capacity corresponded to a removal efficiency of about 14 mgN/l (96%), or 149 kgN/d, of the influent ammonia load applied to the NTFs (average influent flow rate of 10 Ml/d). General concordance was found with corresponding nitrate and nitrite production and alkalinity usage measurements, which substantiated the observed removal performance. This paper details determination of the nitrification capacity of the 2 rock media NTFs used in the prototype ENBNRAS system.

Keywords: full-scale, activated sludge, BNR, nitrification, nitrifying trickling filter

Introduction

In the external nitrification (EN) biological nutrient removal (BNR) activated sludge (AS) system, the nitrification process is removed from the BNR activated sludge system and performed 'externally' on an integrated nitrifying trickling filter (NTF) system (Hu et al., 2000; 2003). As such, optimum design and operation of the NTF system is essential for reliable performance of the ENBNRAS system. Although information on the design and operation of NTFs is well established in the literature (Boller and Gujer, 1986; Lutz et al., 1990; Parker et al., 1989; 1995), this experience is limited to tertiary treatment applications. That is, as an upgrade of conventional wastewater treatment (e.g. activated sludge, aerated lagoon) systems to nitrify the treated effluents to meet ammonia discharge requirements (Lutz et al., 1990). Additionally, NTF design for tertiary treatment typically recommends plastic media, flooding capability for predator control, forced ventilation, continuous dosing and a well clarified secondary treated effluent as influent (Parker et al., 1989; 1995). However, ENBNRAS implementation typically is intended as an upgrade or extension of existing facilities, in which case the NTF specifications are pre-existing (e.g. rock media, natural ventilation). Further, NTF performance as an integral unit process within ENBNRAS systems, particularly in combination with an upstream internal settling tank (IST), is lacking. Where such information has been developed, it has been within the area of research investigating the potential for anoxic P-uptake during denitrification (e.g. Wanner et al., 1992; Bortone et al., 1996; Kuba et al., 1996). The main advantage of anoxic P-uptake is purportedly in using the same substrate for

both BEPR and denitrification (but comes at a cost to BEPR, Hu et al., 2000). However, by focusing principally on anoxic P-uptake, this body of experience provides little and often inappropriate information regarding the performance dynamics of the attached growth NTF, the IST and the optimum operating and design guidelines for the integrated IST-NTF unit process in full-scale ENBNRAS implementation – all of which are essential for accurate characterisation and overall optimisation of the ENBNRAS system. Particularly lacking is appropriate estimation of the nitrification capacity of the NTFs in the ENBNRAS configuration, which is necessary for optimal specification of the NTFs, related flow streams and process loading rates. To remedy this deficiency, in collaboration between the City of Tshwane and University of Cape Town, a full-scale prototype ENBNRAS system was implemented at the Daspoort Wastewater Treatment Works (DWWTW) in Tshwane, South Africa, in 2003 (Muller et al., 2004). This paper describes determination of the nitrification capacity of the rock media NTFs used in this implementation.

Overview of ENBNR implementation at Daspoort WWTW

Detailed descriptions of the design and implementation of the prototype ENBNRAS system at Daspoort WWTW (DWWTW) are contained in Muller et al. (2004). In brief, DWWTW is located in downtown Pretoria and draws influent wastewater from a main collector sewer at an approximately constant rate. The raw wastewater undergoes screening, grit removal and primary sedimentation in Dortmund-type primary settling tanks (PSTs). The main treatment facilities available for the ENBNRAS implementation are listed in Table 1.

The general design approach was to integrate the trickling filters (TFs) of Modules 5-6 with the BNRAS system in Module 9 in the ENBNRAS configuration (Hu et al., 2000). Modules

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