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Nitrogen removal of the simultaneous anammox and denitrification process for treating phenol-containing sewage in a hybrid UASB reactor

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ABSTRACT

A simultaneous anammox and denitrification (SAD) process was applied for removing organic and nitrogen contaminants in an upflow anaerobic sludge blanket (UASB) reactor treating phenol-containing sewage. The morphologies of the granular sludges were further investigated. The results demonstrated that the SAD process could be successfully started up after a continuous operation for 86 d when the hydraulic retention time was maintained at 1.5 h. The removal efficiencies of ammonia, nitrite, and total nitrogen were 85.4%, 86.1%, and 79.9%, respectively. A suppressed anammox bacterial (AMX) activity and a decreased contribution ratio of the nitrogen removal via anammox pathway were observed and resulted from the increased chemical oxygen demand (COD)/NO_x^-–N (COD/N) ratio (≥0.34). Batch substrate degradation tests verified the stable activity of the AMX and denitrification bacteria (DNB) after long-term operation of the optimized SAD process (COD/N ratio of 0.32). Three kinds of granular sludges (anammox, denitrification, and SAD granular sludges) formed at the bottom of the hybrid UASB reactor and originated from the sole anammox granular sludge at the inoculation stage. Photos and scanning electron microscopy images of the SAD granular sludge illustrated the coexistence of the AMX (red, spherical, inner part of the granular sludge) and the DNB (white, short rod, outer part of the granular sludge). Furthermore, the average particle size of the granular sludges increased and the major fraction shifted from 0–1.5 mm (69.4%) to 0.5–2.0 mm (68.9%), indicating the granulation of the sludge mixture by coupling the heterotrophic denitrification process.

Keywords: Nitrogen removal; Anammox; Denitrification; COD/N ratio; Granular sludge characterization

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