Sequential coupling of nitrification-denitrification for simultaneous removal of ammonium, p-cresol and sulfide

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Introduction. Industrial activities such as oil refining, chemical and paper manufacturing have generated wastewaters containing ammonium, sulfide and phenolic compounds with concentrations ranging from one to several hundred mg/L (Olmos et al., 2004). These compounds have been reported to cause environmental and public health damage. Nowadays, in order to remove nitrogen and carbonaceous compounds nitrification-denitrification process is commonly used. Simultaneous removal of p-cresol, ammonium and sulfide by sequential nitrification-denitrification process in the same reactor, and using aerobic granular sludge as inoculum has not been reported. The goal of this study was to evaluate the nitrification-denitrification process via “elemental sulphur” in order to biotransform p-cresol, sulfide and ammonium into CO₂, SO₄²⁻ and N₂, respectively.

Methods. Batch cultures were performed in stirred instrumented experimental units with working volume of 1.0L. Initial sludge concentration was of 3.0 g VSS/L. The air was continually supplied through the reactor liquid phase by using an air sparger at the bottom, reaching a DO concentration of 4.5mg/L. The bioassays were performed by duplicate at 25°C, 200 rpm and pH of 7.0. Culture medium was taken from Beristain-Cardoso et al. (2010). Initial concentrations spiked were 50 mg NH₄⁺-N/L, 100 mg p-cresol-C/L and 100 mg S²⁻/L. Nitrification had a duration of 9h, after that aeration was stopped and residual oxygen was removed by a helium gas flow. NO₃⁻, NO₂⁻, SO₄²⁻, SO₃²⁻, NH₄⁺, N₂, N₂O, p-cresol and VSS were analyzed as was reported by Beristain-Cardoso et al. (2010).

Results. Fig. 1 shows the time course of nitrogenous, sulfurous and carbonaceous compounds consumption during the coupling of nitrification-denitrification process. Three aerobic respiratory processes were performed at the first 5 h, namely: nitrification, sulfide-oxidation and phenolic compound oxidation. After 9 h, aeration was stopped. The S⁰ produced under nitrifying conditions was used after as electron donor to reduce NO₃⁻ to N₂ in the denitrification process. The global analysis of the coupled nitrification-denitrification showed that: ammonium, sulfide and p-cresol consumption efficiencies were above 98%. Soluble organic carbon was detected at lower concentrations (~3.00 mg C/L), suggesting that phenolic compound was mainly mineralized to CO₂. N₂O was transiently produced, but at the end of the batch studies it was completely reduced to N₂. The denitrification end products were SO₄²⁻ and N₂, with yields of 1.04 mg SO₄²⁻/mg S²⁻ consumed and 1.03 mg N₂/mg NH₄⁺-N consumed, respectively. Aerobic granular sludge showed metabolic capability to carry out two biological processes in the same bioreactor: nitrification and denitrification via “elemental sulfur” formation.

Conclusions. In the sequential process of nitrification-denitrification; ammonium, sulfide and p-cresol were successfully removed, being the end products N₂, SO₄²⁻ and CO₂, respectively. The research work evidenced 1) metabolic capability of an aerobic granular sludge to nitrify and denitrify, and 2) that the use of one bioreactor with aerobic granular sludge might be a feasible technology to treat wastewaters of chemical complexity.

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References.