Biodegradation of *o*-nitrophenol by aerobic granules with glucose as co-substrate

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ABSTRACT

Aerobic granules to treat wastewater containing *o*-nitrophenol were successfully developed in a sequencing batch reactor (SBR) using activated sludge as inoculum. Stable aerobic granules were obtained with a clearly defined shape and diameters ranging from 2 to 6 mm after 122 days of operation. The integrity coefficient (IC) and granules density was found to be 98% and 1,054 kg m^{-3} respectively. After development of aerobic granules, *o*-nitrophenols were successfully degraded to an efficiency of 78% at a concentration of 70 mg L^{-1}. GC-MS study revealed that the biodegradation of *o*-nitrophenol occured via catechol via nitrobenzene pathway. Specific *o*-nitrophenol biodegradation rates followed the Haldane model and the associated kinetic parameters were found as follows: $V_{max} = 3.96$ g *o*-nitrophenol $g^{-1}VSS^{-1}d^{-1}$, $K_s = 198.12$ mg L^{-1}, and $K_I = 31.16$ mg L^{-1}. The aerobic granules proved to be a feasible and effective way to degrade *o*-nitrophenol containing wastewater.

Key words | aerobic granules, GC-MS, Haldane model kinetics, *o*-nitrophenol, sequencing batch reactor (SBR)

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INTRODUCTION

Nitrophenols are among the most important and versatile industrial organic compounds and are widely used as raw materials or intermediates in the manufacture of explosives, pharmaceuticals, pesticides, pigments, dye, wood preservatives, and rubber chemicals. (Uberoi & Bhattacharya 1997). Nitrophenol is listed by the US Environmental Protection Agency (USEPA) as priority pollutants owing to its acute toxicity and mutagenic and potential; *o*-nitrophenol possess a significant environmental health risk if released into the environment. Animal studies have demonstrated that nitrophenol can cause blood disorders. Acute exposure of nitrophenol may lead to methemoglobin formation, liver and kidney damage, anaemia, skin and eye irritation, and systemic poisoning (ATSDR 1990, 1992; HSDB 1999). Nitrophenolic compounds have been treated with both aerobic as well as anaerobic processes. However most of the studies have been carried out on pure bacterial culture (Spain & Gibson 1991; Jain *et al.* 1994; Ghosh *et al.* 2010) while very little literature is available related to its treatment in a continuously flowing biological reactor system (Yi *et al.* 2006; Salehi *et al.* 2011). The toxicity of nitrophenols is mainly due to the presence of the nitro group in the aromatic ring. The aerobic degradation of these compounds generally initiate with the removal of nitro group by oxygenase activity (Zeyer & Kocher 1988). Nitro-aromatics possess electron-withdrawing character, rendering difficulty in oxidative attack by oxygenase from aerobic bacteria. Increasing number of nitro groups and electron withdrawing substituent additionally confer susceptibility to electrophilic attack and facilitate reduction of nitro groups. Consequently, nitro-aromatic compounds are readily reduced to more reactive carcinogenic derivatives (Spain 1995).

Three isomeric forms of nitrophenol exist: ortho- (2–), meta- (3–) and para- (4–). Ortho-nitrophenol ($C_6H_4OHNO_2$, abbreviated as ONP) is used in the manufacturing of explosives, pharmaceuticals, synthetic rubber and leather, ortho-nitroanisole and other dyestuffs. Ortho-nitrophenol is listed by the USEPA as an organic priority pollutant. The fate of ONP in wastewater systems is then of interest when sporadic discharges to a POTW are considered as well as in cases of industrial wastewater treatment. Very little information is available on the behaviour of *o*-nitrophenol in aerobic biological wastewater treatment systems. Most of the reported

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