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Effective microbes for simultaneous bio-oxidation of ammonia and manganese in biological aerated filter system

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HIGHLIGHTS

- ▶ Effective microbes for simultaneous bio-oxidation of NH_4^+-N and Mn^{2+} were isolated.
- ▶ Screening test to determine the most effective microbe was performed.
- ▶ Six bacteria were isolated from two conditions of mixed culture.
- ▶ *Bacillus cereus* was the most effective microbe for the bio-oxidation of NH_4^+-N and Mn^{2+}.
- ▶ Simultaneous bio-oxidation of NH_4^+-N and Mn^{2+} was achieved in BAF system.

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ABSTRACT

This study determined the most effective microbes acting as ammonia-oxidising (AOB) and manganese-oxidising bacteria (MnOB) for the simultaneous removal of ammonia (NH_4^+-N) and manganese (Mn^{2+}) from water. Two conditions of mixed culture of bacteria: an acclimatised mixed culture (mixed culture: MC) in a 5-L bioreactor and biofilm attached on a plastic medium (stages of mixed culture: SMC) in a biological aerated filter were isolated and identified using Biolog MicroSystem and 16S rRNA sequencing. A screening test for determining the most effective microbe in the removal of NH_4^+-N and Mn^{2+} was initially performed using SMC and MC, respectively, and found that *Bacillus cereus* was the most effective microbe for the removal of NH_4^+-N and Mn^{2+}. Moreover, the simultaneous NH_4^+-N and Mn^{2+} removal (above 95% removal for both NH_4^+-N and Mn^{2+}) was achieved using a biological aerated filter under various operating conditions. Thus, the strain could act as an effective microbe of AOB and a MnOB for the simultaneous removal of NH_4^+-N and Mn^{2+}.

1. Introduction

Ammonium (NH_4^+-N) removal or nitrification through biological oxidation commonly could be achieved by autotrophic (Sinha and Annachhatre, 2007; Shi et al., 2010) and alternatively removed by heterotrophic bacteria (Ahmad et al., 2008; Zhao et al., 2010). Among the favourable autotrophic nitrifiers that are able to perform the removal are *Nitrosomonas europaea*, *Nitrosomonas halophila* and *Nitrosomonas mobilis*, whereas the heterotrophic nitrifiers involved are the *Bacillus*, *Pseudomonas*, *Comamonas* and *Acinetobacter* species. Due to higher growth rate and activity of heterotrophic bacteria in environments, it provides unfavourable conditions for the autotrophic nitrifying and consequently inhibits the bacteria to grow (Cheng and Chen, 1994). For manganese (Mn^{2+}) removal, *Pseudomonas manganoxidans* (Gage et al., 2001) and *Leptothrix dischopora* SS1 (Zhang et al., 2002) were reported to well oxidise Mn^{2+}. As described in Eq. (1), ammonia-oxidising bacteria (AOB) of heterotrophic nitrifiers oxidise NH_4^+-N by the presence of organic matter as electron donors to yield a new microbial biomass ($C_{10}H_{19}O_3N$) (Metcalf and Eddy, 2004). Meanwhile manganese-oxidising bacteria (MnOB) oxidise Mn^{2+} to form MnO_2 (Mn^{4+}) (Eq. (2)) by releasing −23.7 kJ/mole of free energy (Rygel, 2006).

$$0.02NH_4^+ - N + 0.02HCO_3^- + 0.18CO_2 \xrightarrow{\text{Heterotrophic}} 0.0.2C_{10}H_{19}O_3N + 0.36H_2O \quad \Delta G^0 = 31.8\text{kJ/mole} \tag{1}$$

$$Mn^{2+} + 2H_2O \underset{MnRB}{\overset{MnOB}{\rightleftarrows}} MnO_2 + 4H^+ + 2e^- \quad \Delta G^0 = -23.7\text{kJ/mole} \tag{2}$$

Hasan et al. (2010a) identified a locally isolated *Bacillus* species in mixed culture of sewage-activated sludge (SAS) that had removed

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