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Effect of earthworms on the performance and microbial communities of excess sludge treatment process in vermifilter

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HIGHLIGHTS

- The vermifilter (VF) had higher sludge reduction ability than a biofilter (BF).
- Elemental analysis showed that earthworms enhanced the stabilization of excess sludge.
- Dehydrogenase activity in VF biofilms was much higher than that in the BF.
- Specific microbes in earthworm cast enhanced the degradation of organic matter.

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ABSTRACT

Previous studies have shown that the stabilization of excess sludge by vermifiltration can be improved significantly through the use of earthworms. To investigate the effect of earthworms on enhancing sludge stabilization during the vermifiltration process, a vermifilter (VF) with earthworms and a conventional biofilter (BF) without earthworms were compared. The sludge reduction capability of the VF was ~85% higher than that of the BF. Specifically, elemental analysis indicated that earthworms enhanced the stabilization of organic matter. Furthermore, earthworm predation strongly regulated microbial biomass while improving microbial activity. Denaturing gradient gel electrophoresis (DGGE) analysis showed that the most abundant microbes in the VF biofilms and earthworm casts were *Flavobacterium*, *Myroides*, *Sphingobacterium*, and Myxococcales, all of which are known to be highly effective at degrading organic matter. These results indicate that earthworms can improve the stabilization of excess sludge during vermifiltration, and reveal the processes by which this is achieved.

1. Introduction

Excess sludge is an unavoidable byproduct of the aerobic biological wastewater treatment process. The costs associated with handling this residual product are rising, and thus the search is ongoing for alternative cost-saving techniques to reduce and stabilize excess sludge. This is particularly true for small wastewater treatment plants in developing countries. Accordingly, there is a strong impetus to develop low-cost and ecologically sound techniques to improve sludge reduction and stabilization.

Vermifiltration is a relatively new technology that uses earthworms, and their interactions with microorganisms, to process organically polluted water and excess sludge. Vermifiltration was first developed as an extension of vermicomposting for solid waste in order to treat anaerobically stabilized effluents from the dried vine fruit industry (Athanasopoulos, 1993). Since then, several studies have been conducted to evaluate the use of vermifilters in wastewater treatment (Sinha et al., 2008; Xing et al., 2011a), sludge reduction and stabilization (Zhao et al., 2010), and on-site sludge sanitization (Gajurel et al., 2007). It has been suggested that the enhanced performance of the vermifiltration process for wastewater or excess sludge treatment is due to better aerobic conditions from the burrowing action of earthworms, the greater adsorption effect of the earthworm casts, and higher levels of microbial activity stimulated earthworm feeding (Sinha et al., 2008; Zhao et al., 2010).

Like vermicomposting, vermifiltration is a bio-oxidative process in which earthworms interact intensively with microorganisms

Abbreviations: VF, vermifilter; BF, conventional biofilter; PCR-DGGE, polymerase chain reaction-denaturing gradient gel electrophoresis; DHA, dehydrogenase activity; SS, suspended solids; VSS, volatile suspended solids; SVI, sludge volume index; OLR, organic loading rate; IES, inflow excess sludge; BFS, BF-treated sludge; VFS, VF-treated sludge; VEC, earthworm casts produced by the earthworms in the VF; BF-1, BF biofilm at a depth of 5 cm; BF-2, BF biofilm at a depth of 25 cm; BF-3, BF biofilm at a depth of 45 cm; VF-1, VF biofilm at a depth of 5 cm; VF-2, VF biofilm at a depth of 25 cm; VF-3, VF biofilm at a depth of 45 cm; RDP, Ribosomal Database Project.

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