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Heavy metal distribution and speciation during sludge reduction using aquatic worms

Xiaoqi Zhang [b], Yu Tian [a,b,*], Qiang Wang [c], Lin Chen [b], Xin Wang [b]

[a] State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, China
[b] School of Municipal and Environmental Engineering, Harbin Institute of Technology, Harbin 150090, China
[c] Heilongjiang Provincial Research Institute of Environmental Sciences, Harbin 150056, China

HIGHLIGHTS

- Heavy metal distribution during the reduction of sewage sludge by *Limnodrilus hoffmeisteri* was investigated.
- Heavy metal accumulations in worms during consumption of sewage sludge were described.
- Heavy metal speciation in sludge during predation by worms was determined.
- Effect of heavy metals on the performance of worms for sludge reduction was discussed.

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ABSTRACT

Changes in heavy metal distribution and speciation during the reduction of sewage sludge with the worm, *Limnodrilus hoffmeisteri* were assessed. In sludge containing 108.3 ± 2.2, 455.5 ± 10.3, and 39.4 ± 1.8 mg/kg of Cu, Zn, and Pb, respectively, more than 81% of these metals remained in the sludge after predation by the worms, while 4.1–9.7% of these metals were released into the liquid. The maximum uptake values of Cu, Zn, and Pb by the worms reached 180.5, 587.4, and 55.8 mg/kg, respectively. The predation did not increase metal bioavailability in the final sludge as reflected by a 9.5–12.5% decrease in labile Cu and unchanged levels in labile Zn and Pb. The sewage sludge reduction efficiency of *L. hoffmeisteri* was 27.6–29.2%. These results indicated the relatively moderate changes in speciation and distribution of Cu, Zn, and Pb and the stable performance of worms in reducing sewage sludge.

1. Introduction

Sewage treatment can produce a large amount of sludge. The high expense of traditional sludge disposal options (Liu and Tay, 2001), together with stringent environmental regulations provide impetus for investigating novel sludge reduction techniques. An environmentally-friendly strategy which requires little external energy and brings low secondary pollution is consumption (predation) of sewage sludge by microfauna, such as protozoa and metazoa (Lee and Welander, 1996). When growth of microfauna is promoted in sewage sludge, an extended food chain from pollutants to microfauna is formed. During the transfer of material and energy through the food chain, sludge reduction can be achieved due to inefficient biomass conversion (Ratsak et al., 1993). Some aquatic worms frequently found in wastewater treatment plants (WWTPs) have been proposed to reduce sludge, such as Tubificidae, Lumbriculidae, and Aeolosomatidae. Tubificidae (e.g. *Limnodrilus hoffmeisteri* and *Tubifex tubifex*) have high consumption rates, a long life span and a superior capacity to tolerate the pollutants and toxic compounds in aquatic ecosystems (Lucan-Bouche et al., 1999). Such advantages indicate that such organisms might be the ideal predators for reducing sewage sludge.

An actual application of worms for sludge reduction has only recently been implemented (Lou et al., 2011; Tamis et al., 2011). Different worm-reactors for sludge reduction have been developed to produce suitable conditions for worm growth (Guo et al., 2007; Hendrickx et al., 2009, 2011; Huang et al., 2007; Tamis et al., 2011; Tian et al., 2010; Wei et al., 2009a). The concentrations of carbon, nitrogen and phosphorus within the effluents of worm-reactors were measured (Guo et al., 2007; Hendrickx et al., 2010; Huang et al., 2007; Tamis et al., 2011; Wei et al., 2009a) and the results indicated a significant release of nutrients into the effluents. Wei et al. (2009b) described the phosphorus distribution

* Corresponding author at: School of Municipal and Environmental Engineering, Harbin Institute of Technology, Harbin 150090, China. Tel./fax: +86 451 8628 3077.
E-mail address: hittianyu@163.com (Y. Tian).

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