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Effects of micro-nano and non micro-nano MSWI ashes addition on MSW anaerobic digestion

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ABSTRACT

This study aims at investigating the effects of micro-nano municipal solid waste (MSW) incinerator (MSWI) fly ash (FA) and bottom ash (BA) on the MSW anaerobic digestion. Results showed that suitable micro-nano and non micro-nano MSWI ashes addition (FA/MSW 3, 6, 18 and 30 g g^{-1} VS and BA/MSW 12, 36, 60 and 120 g g^{-1} VS) could enhance the biogas production compared to the control. It was particularly found to have the highest biogas production at the micro-nano MSWI BA/MSW ratio of 36 g g^{-1} VS (~193 mL g^{-1} VS MSW, ~3.5 times to the control). Micro-nano MSWI FA and BA added bioreactors had the higher biogas production than the corresponding non micro-nano MSWI FA and BA added ones. Suitable MSWI ashes addition could improve the biogas production due to the released metals levels suitable for the MSW anaerobic digestion particularly found in the micro-nano added bioreactors.

1. Introduction

Municipal solid waste (MSW) has been mainly treated by MSW incinerator (MSWI) while partly treated by landfilling, resource recovery, composting and gasification in Taiwan. The MSWI could reduce the MSW volume and have the potential co-generation benefit of the steam and electricity while it also produces the residues such as bottom ash (BA) and fly ash (FA). MSWI BA and FA were reported to contain various metals and recalcitrant organic compounds such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzodioxins/furans (PCDD/Fs). Both BA and FA could be used as aggregate, backfill, soil amendment and cement additives after careful pretreatment, toxicity and TCLP test (Lin and Chen, 2006).

Studies on BA or FA on co-disposal or co-digestion with MSW were few (Lo et al., 2010, 2009; Lo and Liao, 2007; Boni et al., 2007). MSWI BA and FA addition might release various metals levels resulting to the potentially beneficial or detrimental effects on the MSW anaerobic digestion (Lo et al., 2009). However, beneficial facilitation of MSW biodegradation by ash addition was still not well understood. Similar investigations were also reported that metals of different levels might stimulate or inhibit the organic substrate anaerobic digestion and fermentation process (Fermoso et al., 2009; Chen et al., 2008; Yuan et al., 2009; Tan et al., 2009; Altaş, 2009; Li and Fang, 2007; Lin and Shei, 2008; Yue et al., 2007; Kuo and Genthner, 1996; Gikas, 2007; Kida et al., 2001; Ma et al., 2009; Worm et al. 2009). Recently, Lo et al. (2012) have incorporated the above research and reported the new results that suitable levels of several individual metals could enhance the MSW anaerobic digestion. On the other hand, PAHs and PCDD/Fs of MSWI ashes and their release were investigated by several researchers and their adsorption by adsorbents and biodegradation by microorganisms were also reported (Wyrzykowska et al., 2009; Lin et al., 2008; Yasuhara and Katami, 2007; Wang et al., 2010; Ham et al., 2008; Liu et al., 2008; Nam et al., 2005; Shitamura et al., 2005; Oleszczuk, 2009).

Nanotechnology has been evolved to be an attractive option in engineering and environmental science. Mu and Chen (2011) has reported that the presence of 1 mg g^{-1}-TSS of ZnO nanoparticles (NPs) did not affect methane production of waste activated sludge, but 30 and 150 mg g^{-1}-TSS of ZnO NPs induced 18.3% and 75.1% of inhibition, respectively. Mu et al. (2011) has also investigated the metal oxide nanoparticles (TiO_2, Al_2O_3, SiO_2 and ZnO) on waste activated sludge anaerobic digestion. Nano-TiO_2, nano-Al_2O_3 and nano-SiO_2 in doses up to 150 milligram per gram total suspended solids (mg g^{-1}-TSS) showed no inhibitory effect, whereas nano-ZnO showed inhibitory effect with its dosages increased. The methane generation was the same as that in the control when in the presence of 6 mg g^{-1}-TSS of nano-ZnO, however, which decreased respectively to 77.2% and 18.9% of the control at 30 and 150 mg g^{-1}-TSS. The released Zn^{2+} from nano-ZnO was an important reason for its inhibitory effect on methane generation. Luna-delRisco et al. (2011) found that particle size of CuO and ZnO could

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