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The Effects of Nano Zerovalent Iron (nZVI) and Magnesium Oxide Nanoparticles on Methane Production during Anaerobic Digestion of Waste Activated Sludge

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Abstract : Many studies have been reported that the nZVI and MgO NPs were often found in waste activated sludge (WAS). However, little is known about the impact of those NPs on WAS stabilization. The aims of this study were to investigate the effects of both NPs on WAS anaerobic digestion for methane production and to examine the change of metanogenic population under those different environments using qPCR. Four dosages (2, 50, 100, and 200 mg/g-TSS) of MgO NPs were added to four different bottles containing WAS to investigate the impact of MgO NPs on methane production during WAS anaerobic digestion. The effects of nZVI on methane production during WAS anaerobic digestion were also conducted in another four bottles using the same methods described above except that the MgO NPs were replaced by nZVI. A bottle of WAS anaerobic digestion without nanoparticles addition was also operated to serve as a control. It was found that the relative amounts, compared to the control system, of methane production in each WAS anaerobic digestion bottle adding 2, 50, 100, 200 mg/gTSS MgO NPs were 98, 62, 28, and 14 %, respectively. This suggests that higher MgO NPs resulted in lower methane production. The data of batch test for the effects of corresponding released Mg2+ indicated that 50 mg/gTSS MgO NPs or higher could inhibit methane production at least 25%. Moreover, the volatile fatty acid (VFA) concentration was 328, 384, 928, 3,684, and 7,848 mg/L for the control and four WAS anaerobic digestion bottles with 2, 50, 100, 200 mg/gTSS MgO NPs addition, respectively. Higher VFA concentration could reduce pH and subsequently decrease methanogen growth, resulting in lower methane production. The relative numbers of total gene copies of methanogens analyzed from samples taken from WAS anaerobic digestion bottles were approximately 99, 68, 38, and 24 % of control for the addition of 2, 50, 100, and 200 mg/gTSS, respectively. Obviously, the more MgO NPs appeared in sludge anaerobic digestion system, the less methanogens remained. In contrast, the relative amount of methane production found in another four WAS anaerobic digestion bottles adding 2, 50, 100, and 200 mg/gTSS nZVI were 102, 128, 112, and 104 % of the control, respectively. The measurement of methanogenic population indicated that the relative content of methanogen gene copies were 101, 132, 120, and 112 % of those found in control, respectively. Additionally, the cumulative VFA was 320, 234, 308, and 330 mg/L, respectively. This reveals that nZVI addition could assist to increase methanogenic population. Higher amount of methanogen accelerated VFA degradation for greater methane production, resulting in lower VFA accumulation in digesters. Moreover, the data for effects of corresponding released Fe2+ conducted by batch tests suggest that the addition of approximately 50 mg/gTSS nZVI increased methane production by 20%. In conclusion, the presence of MgO NPs appeared to diminish the methane production during WAS anaerobic digestion. Higher MgO NPs dosages resulted in more inhibition on methane production. In contrast, nZVI addition promoted the amount of methanogenic population which facilitated methane production.

Keywords : magnesium oxide nanoparticles, methane production, methanogenic population, nano zerovalent iron
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