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Synergetic treatment of sewage sludge and food waste for biogas generation and heavy metals immobilization via anaerobic digestion and pyrolysis

C. Li[a,b], S. Xie[a], X. Zhu[b], R. Tian[a], I. Angelidaki[b] and Y. Wang[a]

[a]Key Laboratory of Urban Pollutant Conversion, Institute of Urban Environment, Chinese Academy of Science, Xiamen 36102, China
[b]Department of Environmental Engineering, Technical University of Denmark, Kgs. Lyngby, DK-2800, Denmark (E-mails: chuli@env.dtu.dk, syxie@iue.ac.cn, xinzh@env.dtu.dk, rqtian@iue.ac.cn, iria@env.dtu.dk, yinwang@iue.ac.cn)

Abstract: In this study, a novel method was proposed for synergetic treatment of sewage sludge and food waste. First, the sewage sludge was hydrothermally treated to improve its dewaterability. The separated filtrate from hydrothermally treated sewage sludge (HS) and food waste co-digested for biogas generation. The obtained digestate residue (DR) was used for co-pyrolysis with sludge filter cake from HS for heavy metals immobilization. The obtained results showed that the methane yield of filtrate was significantly increased with addition of food waste and the lag phase during the digestion of food waste was shortened during co-digestion. In terms of heavy metals immobilization, the heavy metals in sewage sludge were immobilized during co-pyrolysis process. Moreover, the higher DR content led to better immobilization effect. These above results provided the feasibility for more efficient and safer synergetic treatment of sewage sludge and food waste.

Keywords: sewage sludge; food waste; anaerobic digestion; pyrolysis; biogas; heavy metal immobilization

Session .. – *Sludge and slurry digestion (waste activated sludges, energy crops, co-digestion, sludge dewaterability, etc.)*

Introduction

With the rapid urbanization and the improvement of living standard in China, large amount of sewage sludge and food waste are produced, and their disposal and energy recovery are becoming an urgent problem (Li et al. 2017). In fact, the poor sewage sludge dewaterability is the limit step for its subsequent treatment and utilization. Among different treatment methods to improve sewage sludge dewaterability, hydrothermal pretreatment was extensively used for its relatively high efficiency and good performance (Neyens et al. 2003). Another problem restricting the use of sewage sludge is that it contains high concentration of heavy metals (Shi et al. 2013). On the other hand, the food waste is often treated with anaerobic digestion to produce biogas. However, the acidification occurred during anaerobic process and the final valorisation of digestate are the main challenges. So, synergetic treatment of sewage sludge and food waste to accomplish higher energy recovery and safer treatment attracts much interest and attention. In the present study, the filtrate from HS was used for co-digestion with food waste for higher biogas production, and then the DR was added during pyrolysis of sewage sludge filter cake for better heavy metals immobilization.

Material and Methods

The HS was obtained from a pilot-scale plant for sewage sludge dewatering and pyrolysis. The food waste was acquired from a local restaurant. The anaerobic digestion and pyrolysis experiments were conducted according to our previous study (Li et al. 2018). The methane content and heavy metals analysis were measured using the Agilent Micro 3000-GC and a three-step BCR extraction procedure, respectively, and detailed information could be found in our previous research (Wang et al. 2016).

Results and Conclusions

Co-digestion of filtrate and food waste for methane enhancement

The cumulative methane yields from co-digestion of filtrate and food waste under different ratio are presented in Figure 1. The results showed that methane production of the filtrate was significantly enhanced with adding food waste, and more food waste added lead to higher methane yield. This observation is attributed to the high methane generation potential of food waste. And also, the lag phase during the digestion of food waste was significantly shortened with addition of filtrate. It is known that food waste anaerobic digestion could easily suffer from VFAs accumulation, because it has a high acidogenesis rate. The results showed that the inhibition from VFAs during food waste fermentation was well eased during co-digestion. These results indicated that the co-digestion can clearly improve the methane yield of filtrate and shorten t lag phase during the digestion of food waste.

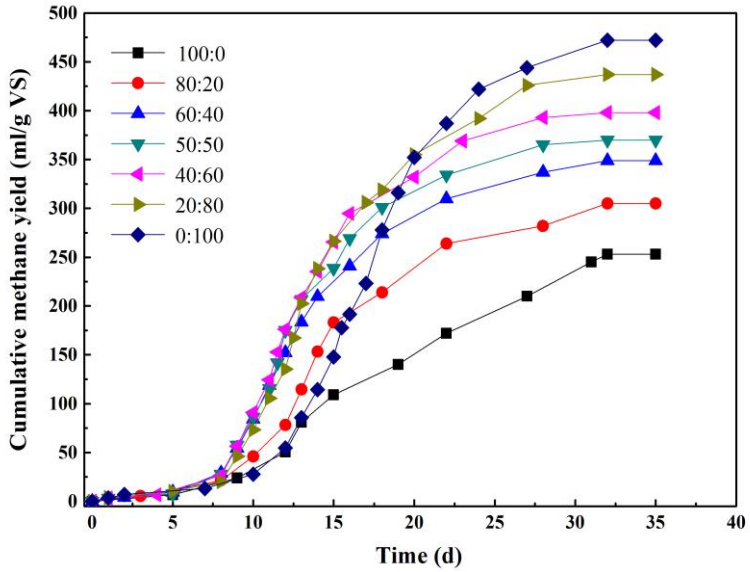

Figure 1 Cumulative methane yields from co-digestion of filtrate and food waste under different mixing ratio (Filtrate : Food waste).

Co-pyrolysis of HD and DR for heavy metals immobilization

The bioavailability and toxicity of heavy metals on the environment are mainly related to their chemical speciations. The chemical speciations assessed by BCR sequential extraction scheme can be divided into four fractions: F1, acid soluble and exchangeable fractions; F2, reducible fraction; F3, oxidizable fraction and F4, residual fraction. The bioavailability and mobilization of each fraction were lowered sequentially (F1 > F2 > F3 > F4). The fractions distribution of different heavy metals (Zn, Cu, Cd and Pb) in all samples are presented in Figure 2. The results showed that the stable fractions of F3 + F4 in HS increased in its biochar sample (HSC) after pyrolysis. The proportion of the stable fraction further increased with co-pyrolysis with DR and more DR ration resulted in higher F3+F4 proportion. And also, the co-pyrolysis with DR could also reduce the concentrations of different kinds of heavy metals in HSC resulting from the low heavy metals concentration in DR. The increase in F3 + F4 fractions indicated the reduce in environmental risk of the biochar samples.

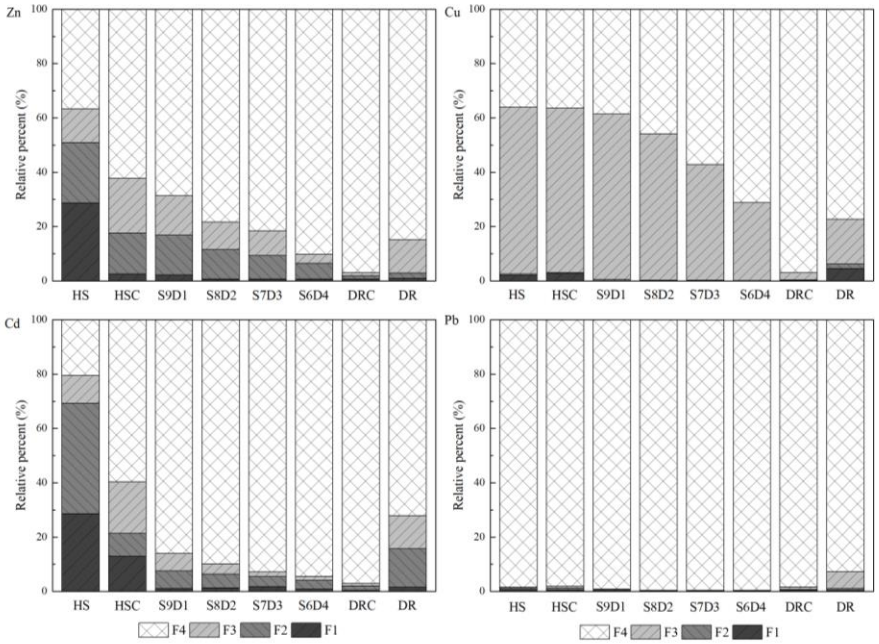

Figure 2 Fractions distribution of different heavy metals (SXDY: biochar samples from co-pyrolysis of HS and DR with ratio of X:Y).

In conclusion, the synergetic treatment of sewage sludge and food waste via co-digestion and pyrolysis can significantly benefit the biogas production and heavy metals immobilization. This method also raised the energy output from sewage sludge and food waste treatment and reduced the environmental risk of residual disposal.

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