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On site composting of food waste: A pilot scale case study in China

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ABSTRACT

Composting is one of the effective strategies to treat excessive amount of food waste (FW). In this study, the mode of source separation by residents – composting in situ with complete equipment (CPEM) was proposed. Pilot scale facility covering 132 m^2 was constructed and operated to treat FW (6 t/d). Results showed that the composting CPEM including feeding, breaking, dewatering, spiral boosting, composting reactor, odor biofilter, aeration system, and rotating device units was operated stably over two years. During 10 days drum composting, the temperature of FW experienced three classic phases including heating phase, thermophilic phase, and cooling phase. The concentration of H_2S and NH_3 in the effluent were as low as 0.0001 and 0.025 mg/m^3 after biofiltering treatment. After 20 days subsequent post-maturity, total content of N, P and K in the FW compost was as high as 11.66%. When the compost was applied to pakchoi (*Brassica chinensis* L.), the content of vitamin C and soluble sugar increased 18.78% and 38.49%, and the content of nitrate and nitrite decreased 46.86% and 51.89%, respectively. As for economical consideration, the average investment and energy consumption of the CPEM were as low as US$ 61.5 and 50.0 kWh/t. The successful case of the pilot scale plant suggested that the mode of source separation-composting in situ with CPEM was feasible to realize the recycling of FW.

1. Introduction

Food waste (FW), a type of organic waste, comes from a variety of sources including restaurants, canteens, households and so on. FAO (2016) reported that human consumption wasted a large number of the food (1.3×10^9 t/y). Accounting for a considerable portion of household solid waste (HSW) (Kiran et al., 2014), disposal of FW along with the HSW increased the pressure of end control and simultaneously caused siting difficulty of landfill facility (Hoornweg et al., 2013). The worldwide governments have to confront this challenge regularly for all previous disposal approaches are no longer acceptable (Rada et al., 2013). Simultaneously, people will pay more attention to keep a balance between progress, quality of life and environment in the future (Rada et al., 2013). With the further increasing production (Lai et al., 2011) and the generating environmental, economic and social impacts of FW (Malamis et al., 2017), the reasonable and efficient disposal of FW is becoming one of the major worldwide concerns.

FW was generally disposed with other HSW components by landfill or incineration (Lee et al., 2007). The centralized landfill and incineration could realize the harmlessness of FW, but it still showed drawbacks such as secondary pollution from leachate, landfill gas leakage (Slack et al., 2005), dioxins, and heavy metals (He et al., 2004). Source separation (SS) and separate collection of FW, a common practice applied especially in EU countries (Moh and Manaf, 2017), successfully helped to improve FW recycling and recovery efficiency (Malamis et al., 2017). Various strategies have been applied to treat the source separated FW, such as anaerobic digestion (Jensen et al., 2017), biofuels production (Thi et al., 2016), and oil recycling by solid-liquid separation (Sealey and Smith, 2014).

FW contains over 90% of organic matter (OM) with 80% moisture (Meng et al., 2015), which makes FW a potential high-quality raw material for biological treatment. Composting has proven to be an attractive measure to deal with FW for less environmental pollutants (Wei et al., 2017) and useful final product (Benito et al., 2006). Successful pilot scale FW composting have been reported previously. Kim et al. (2008) found that the pilot-scale in-vessel composting system was conducive to the maintenance of aerobic condition (over 6% oxygen concentration in off-gas) through the entire compost bay to produce the satisfactory final compost for agricultural application. Pandey et al. (2016) operated an in-vessel co-composting system of food and green

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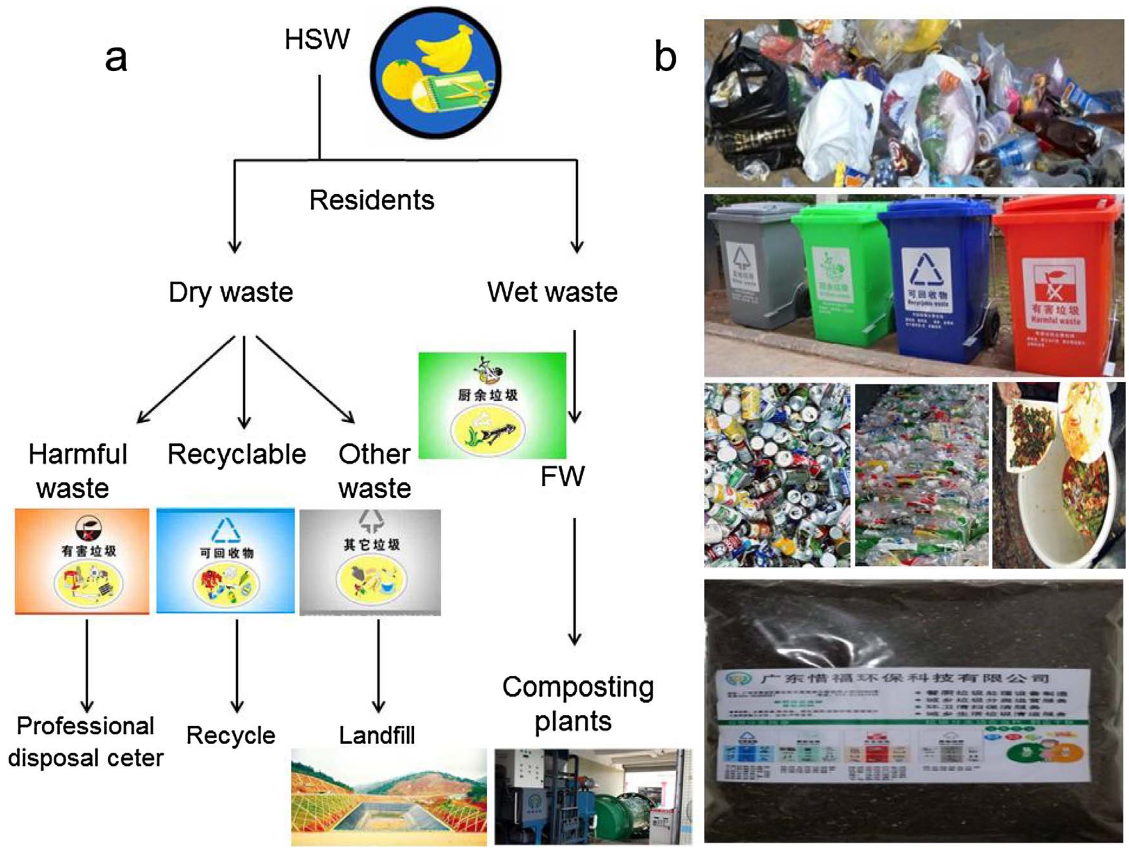

Fig. 1. The flow chart (a) and schematic diagram (b) of garbage classification.

waste with external heat and continuous mixing and attained a successful mode of enhancing sustainable agriculture by boosting the decomposing of OM into pathogen-free soil amendment. However, a favorable FW composting system is expected to be not only cost effective but also environmentally friendly, which benefits the promotion of composting technology (Liu et al., 2017).

The FW management tasks must be identified and implemented according to the waste hierarchy, including reduction, reuse, recycle, recovery, and disposal, for FW might produce greenhouse gas emissions and therefore has an impact on climate change (Isabelle, 2014). Various of policies have been undertaken to encourage FW reduction, recycling and utilization as resources to lower the cost of managing landfills, pollution impacts and public health threats. EU in line with the Landfill directive (EU, 1999) has become increasingly focused on energy and nutrient recovery as opposed to landfilling in coming years. At the same time, the U.S. and abroad have gradually attached importance on FW prevention and recovery, which reflected in federal and state policies (Platt and Goldstein, 2014). Options such as anaerobic digestion, composting and biofuel production have been well investigated for FW management (Carlsson et al., 2015).

Recent years have witnessed the raised attention of FW all over the world. The EU Member States addressed FW as one of programs in their national waste prevention and required to halve FW by coordination measures before 2025 (European Parliament, 2012), and the EC determined to put FW in priority disposal areas of the EU Action Plan for Circular Economy in 2015 (European Commission, 2015). In September 2015, the United Nations (UN) introduced the target of reducing per capita FW globally by 50% at the retail and consumer levels by the year 2030 for Sustainable Development (United Nations, 2015). Both prevention and recovery programs have been carried out in US, which aimed to reduce the generation of FW and to divert FW from disposal (landfill or incineration) to biological treatment such as composting or anaerobic digestion (Thyberg and Tonjes, 2016).

China has also continued to strengthen the reuse of HSW, especially the organic waste (Yong, 2012). In 2011, the State Council approved the opinions on further strengthening HSW disposal, and attempted to control the generation of HSW from the source and to promote the classification of HSW (The State council, 2011). Achieving the goals of classified collection and complete disposal of HSW, the implementation plan of HSW classification system was issued by The State Council (2017). The plan requires relevant departments to strengthen the monitoring and transportation of FW. It also encourages to reuse FW to produce industrial oils and fats, biodiesel, feed additives and soil conditioners. The Chinese government raised the idea of the substitution of organic fertilizer (OF) for traditional chemical fertilizer in “NO. 1”s document in 2017 (The Central People’s Government of the People’s Republic of China, 2017). Long-term inappropriate chemical fertilizer application has led to the severely degraded soil in China with high acidity, low nutrients, and a disturbed and unbaanced ecosystem (Chen et al., 2009). It has an urgent demand to improve its fertility and change its functional structure with the blend of OF such as FW compost (Li et al., 2013).

Herein, we proposed a mode of source classification of residents – composting in situ and designed a set of complete equipment (CPEM) for FW composting. It aimed to decrease energy consumption and improve the quality of the final compost. To evaluate the feasibility and stability of SS and composting in situ CPEM of a pilot scale composting plant, the technical and economic indexes of composting system was comprehensively assessed. The pot experiment was designed with addition of FW fertilizer to test the quality of the compost. The results obtained from this case study can promote the development of SS FW on-site composting technology and motivate the application of CPEM in large FW producers like urban residential area.