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Comparison of the food waste degradation rate and microbial community in the matrix between two biodegradation agents in a food waste disposer

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ABSTRACT

To reduce the proportion of food waste in municipal solid waste, a food waste biodegradation experiment with two biodegradation agents was conducted for seven weeks with 500 g of food waste added every day into each disposer. The agent containing four biodegradation bacterial strains showed higher degradation rates and matrix temperatures than that containing two. Furthermore, significant differences in the microbiological community structures of the matrixes were found not only between the two biodegradation systems but also among different stages in the same degradation system based on DGGE profiles. The F2 strain exhibited the highest DGGE optical density (OD) value among biodegradation systems and at all experimental stages, suggesting it was a dominant strain during food waste degradation.

1. Introduction

In recent years, city managers have been faced with the serious challenge of disposing of the huge amount of municipal solid waste (MSW) generated by the acceleration of urbanization in China. Incineration and landfill are the most common methods adopted for MSW disposal at present (Uberoi, 2003), which both have respective advantages and disadvantages. Though incineration reduces MSW to a minimum quantity, it poses a threat to the environment by producing toxic gases like dioxin (Kim and Kim, 2010). Landfill is relatively cheap but occupies vast land resources, leads to serious secondary pollution such as methane gas, which has significantly higher impact on global warming than does carbon dioxide (Kwon et al., 2011), and releases leachates into underground water systems. These issues are caused and exacerbated by the high proportion of perishable food waste in MSW. The disadvantages of incineration and landfill could be reduced by decreasing the proportion of food waste in MSW.

Food waste produced during consumption and food preparation (Ueta and Koizumi, 2001) contains high water and organic matter content, resulting in strong odors due to microorganism contamination during collection, transportation and processing (Lin et al., 2011). On the other hand, food waste is a good resource for animal feed, compost and biomass energy because of its rich organic matter (Yan et al., 2012). Food waste generated at hotels, restaurants and canteens could be reused as a source of feed, compost or biofuel due to the large volume and easy collection. While the relatively small amounts of food waste produced in homes are unsuitable for intensive utilization, scavenging this waste in situ by biodegradation systems may be feasible (Bernstad and la Cour Jansen, 2012).

The major components of food waste include polysaccharides such as starch, protein, lipid and cellulose (Zhang et al., 2013). To enhance the efficiency of biodegradation systems, several strains of bacteria used to effectively break down protein, starch, cellulose and grease found in food waste into carbon dioxide, water vapor and ash, and transform them into humus were screened and identified in our previous work. However, it is unclear whether different combinations of bacterial strains in biodegradation systems can influence food waste elimination efficiency or which functional strains are dominant in biodegradation systems. To address these problems, a food waste biodegradation experiment using two combinations of functional strains was conducted for seven weeks and the dynamic structures of the microbial community in the biodegradation systems were detected by PCR-DGGE fingerprinting (Cherif et al., 2008).

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2. Materials and methods

2.1. Food waste disposer

Fig. 1 shows the food waste disposer employed in this study, which was supplied by Ningbo Tongyong Plastic Machinery Manufacturing Co., Ltd. (Ningbo, China). The biodegradation agent and drained food waste were added into the container of the disposer, and the lid was closed. The biodegradation agent consisted of a mixture of special functional microbial strains and a carrier. The agent and waste were mixed sufficiently in the disposer with an air supply under stirring mode. The functional strains in the agent decomposed most of the organic fraction into H_2O and CO_2 as well as some residues under aerobic conditions. Moisture was removed with an exhaust and drying device. The residues became part of the agent. Later, drained food waste was placed into the disposer at any time.

2.2. Functional strains and carrier of the biodegradation agents

The functional bacterial strains used for waste decomposition were *Bacillus subtilis* (F2), *Paenibacillus* (F5), *Bacillus cereus* (F6) and *Pseudomonas* (F7), *Paenibacillus polymyxa* (F8), which were isolated, screened and identified in our previous work. Mulberry branch sawdust pieces (<2 cm) were applied as biodegradation agent carriers.

2.3. Experiment design

The food waste experiment using two biodegradation agents was conducted over seven weeks. Agent-1 contained two functional strains i.e. *Bacillus subtilis* (F2) and *Paenibacillus polymyxa* (F8), and Agent-2 included four strains, i.e. *Bacillus subtilis* (F2), *Paenibacillus* (F5), *Bacillus cereus* (F6), and *Pseudomonas* (F7). The culture solution of each strain contained 10^8 CFU/ml (CFU: Colony Forming Units, the number of active bacteria per volume) and was prepared by fermentation in monosodium glutamate waste liquid diluted 80 times with the pH adjusted to about 7.0 at 30 °C for 48 h. The biodegradation agent was composed of 2 kg of mulberry sawdust, 1.5 L of mixed culture solution and 0.5 L of water. The mixed culture solution of each agent was blended with the culture solution of each strain in the same volume ratio.

During food waste biodegradation, 500 g of drained food waste collected from the canteen of Zhejiang University was put into the disposer at 12:00 pm every day. The matrix in the disposer, which was the residue of food waste and the degradation agent after a period of biodegradation, was sampled just before new food waste was added once a week. Samples were kept at −80 °C for further analysis.

A control following the fore-mentioned procedure but without the functional strains was also carried out.

2.4. Measurement methods

2.4.1. Gross waste food degradation rate

$$\text{Gross waste food degradation rate}(\%) = [C - (B - A)]/C * 100\%$$

where A: total weight of the degradation agent and disposer at the beginning of a running period; B: weight of the residue matrix and disposer after running for a period of time; C: dosage of waste food added.

2.4.2. Matrix temperature

The matrix temperatures in the disposers with Agent-1 and Agent-2, denoted as T_1 and T_2, respectively, were detected by a mercurial thermometer in situ 2 h after food waste was added every day. Ambient temperature (T_0) was recorded at the same time. The difference between T_1/T_2 and T_0 on a same day was the increase in the temperature of the matrix ($\triangle T$), i.e. $\triangle T_1 = T_1 - T_0$

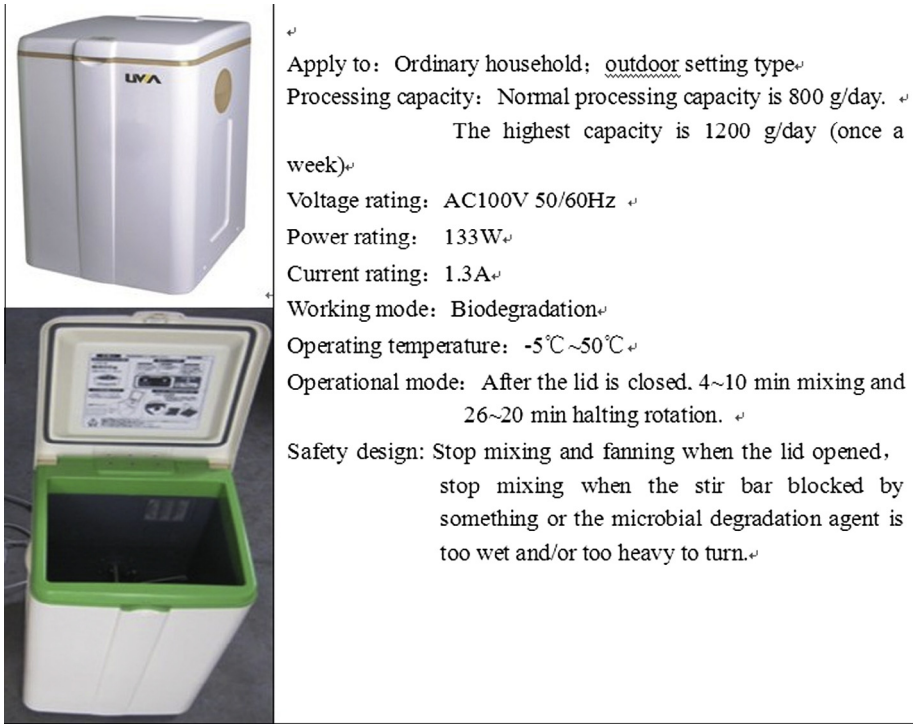

Fig. 1. Food waste disposer and its design parameters.