Turning Food Waste into Treasure

Introduction

Hong Kong is facing an imminent and serious food waste problem. In recent years, the amount of food waste generated daily has shown an increasing trend, from 3,155 tonnes in 2002 to 3,584 tonnes in 2011 (Figure 1). According to the report *"Monitoring of Solid Waste in Hong Kong 2011"* released by the Environmental Protection Department (EPD) of the Hong Kong Special Administrative Region Government, food waste was the major component in the municipal solid waste, accounting for almost 40% of the MSW in 2011. In fact, most of the food waste in Hong Kong is from the domestic sector, contributing about 70% to the total food waste generation while the remaining 30% is from the commercial and industrial sector.

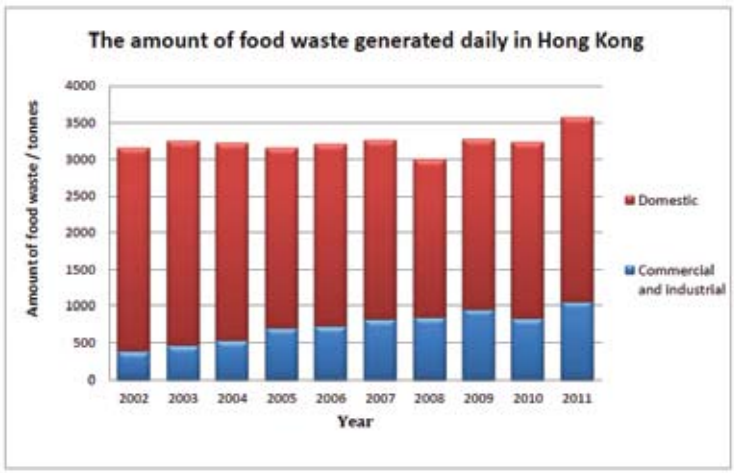

Figure1. The amount of food waste generated daily in Hong Kong from 2002 to 2011 (EPD, 2011).

Until very recently, the only way to deal with food waste is to dump it directly to landfills. Such an approach not only aggravates the global warming effect due to the emission of landfill gas, but also loses valuable opportunities for food waste regenerations like energy recovery, composting, animal feed and platform chemical production. Furthermore, waste-to-landfill is neither an environmental friendly nor a sustainable option, especially when all the existing landfills in Hong Kong are expected to be filled up within the next few years. We have seen recent strong opposition to any expansion of these landfills by the nearby residents. Thus, extensive efforts must be made to divert food waste from landfills through what is known as "waste valorization" technologies.

Some common food waste valorization technologies such as composting, animal feed production, and conversion to biogas have been adopted around the world for a long time. However, for Hong Kong, agriculture represents only a very small part of our economy. Therefore, composting and animal feed production will not be profitable in view of the low demand of compost and animal feed. In fact, many property management companies find it hard to dispose of the compost they create from their residential complexes. In addition, the composting technique requires large amounts of electricity and hence has a positive impact on our carbon footprint.

In the following, we describe two approaches to reduce the amount of food waste that goes into the landfills, with the possibility of eventually eliminating the need to dump any such waste to the landfill.

Articles to Share

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Turning food waste to biogas

Turning food waste to methane or biogas with biological technology is a mature solution to treat food waste for the dual purposes of solid waste management and generating energy. Biogas facilities to treat food waste are quite common in European countries such as England and Germany. In Hong Kong, the EPD has planned to establish two Organic Waste Treatment Facilities to turn food waste to biogas and compost (Figure 2). One of the facilities is to be located at Siu Ho Wan (Phase I) and another one at Shaling (Phase II). When both facilities are in full operation in the future, the total treatment capacity is 400 to 500 tons of food waste per day. The Siu Ho Wan facility is scheduled to begin construction in March 2014 and in operation by June 2016.

At the School of Energy and Environment (SEE) of City University of Hong Kong (CityU), we are interested in studying the feasibility of turning the food waste generated in Hong Kong to methane at the laboratory scale. The science behind this biological technology is of interest in its own right as the process is carried out by a complex group of microorganisms. Hence, research has to be carried out to investigate how the microorganisms are breaking down the food waste and subsequently producing the methane so that we can maximize such production. With support from the Research Grants Council of Hong Kong, we have found that it is possible to turn food waste to a high concentration of methane. Furthermore, if the methane from the 1.3 million tonnes of food waste generated each year in Hong Kong is fed into gas turbines to generate electricity, it is estimated that the energy output is enough to provide about 1-2% of Hong Kong's electricity consumption (i.e. around 0.4-0.8 billion kWh). Even though the output remains a small percentage of our energy consumption, this treatment technology serves three important purposes: (1) it diverts food waste away from landfills to lessen their burden; (2) the electricity produced can reduce the use of fossil fuels; and (3), the reduced consumption of fossil fuels in essence lowers the carbon footprint of Hong Kong.

Turning waste into useful products

Another approach to valorize food waste developed at SEE is a novel "biorefinery" process that can effectively convert food waste into valuable chemicals without carbon emission. This process utilizes enzymes and bacteria to convert food waste into succinic acid, which is a chemical widely applied to form the basis of many compounds for home and industrial uses.

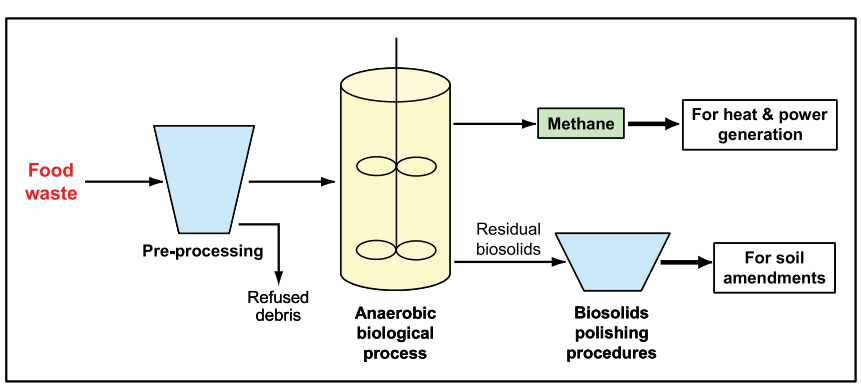

Figure 2. Schematic showing how food waste can be converted to biogas and fertilizers.

During the process, food waste is first blended with two kinds of enzyme-secreting fungus to break down the carbohydrates and proteins in food respectively into simple sugars and nitrogen

Turning Food Waste into Treasure (cont'd)

compound. Then, bacteria are added to undergo fermentation utilizing the simple sugars and nitrogen compound to produce succinic acid, which is widely used as a flavouring agent by the food and beverage industry and as an ingredient to manufacture biodegradable plastics, fabrics, surfactants, paints, etc. As an important "bonus", the remaining solid biomass can be used as soil fertilizer (Figure 3).

At SEE, we have applied the process to bakery waste and mixed food waste from CityU's canteens. The results are very promising: 1000 kilograms of food waste can be utilized to produce 100-240 kilogram of succinic acid.

Because of its wide applications, succinic acid has always been in high demand. It is currently produced from petroleum, which is energy-intensive (and thus a high carbon footprint) and not sustainable. Our biorefinery process to produce succinic acid through the use of food waste should therefore be a viable, cost-effective and environmental friendly alternative. We have conducted a techno-economic study with a conclusion that a plant should be able to generate profit after five years with a return rate of close to 20%.

Concluding remarks

While the downstream technology to treat food waste to produce biogas and succinic acid maybe feasible, one of the barriers or challenges we need to overcome in order to make the treatment process a success is in the upstream stage to separate the food waste at source from other garbage and recyclable materials at the residential and commercial settings. Most importantly, for the production of biogas, non-biodegradable materials cannot be mixed with food waste or it will hinder the efficiency and biogas yield of the treatment facility. For the production of succinic acid, a more homogeneous type of food waste will give a higher yield and purity of the acid. In reality, collecting food waste in Hong Kong is not a trivial task as every household and restaurant generates food waste, which means that the existence of a huge number of sources of food waste dispersed in multiple locations. Since food waste is perishable, hygiene and public health issues must also be considered during collection and disposal. Therefore, collecting food waste in Hong Kong will require some innovative strategies and change of habits from the citizens.

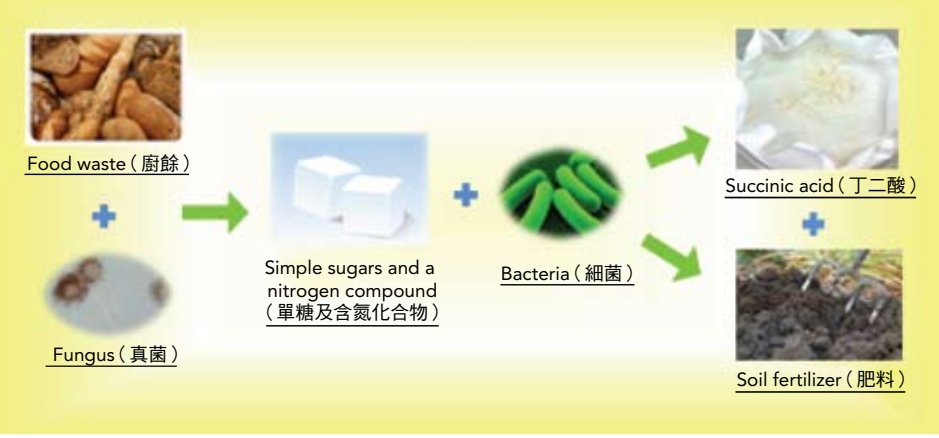

Figure 3. Schematic showing how food waste can be converted to succinic acid and fertilizer.

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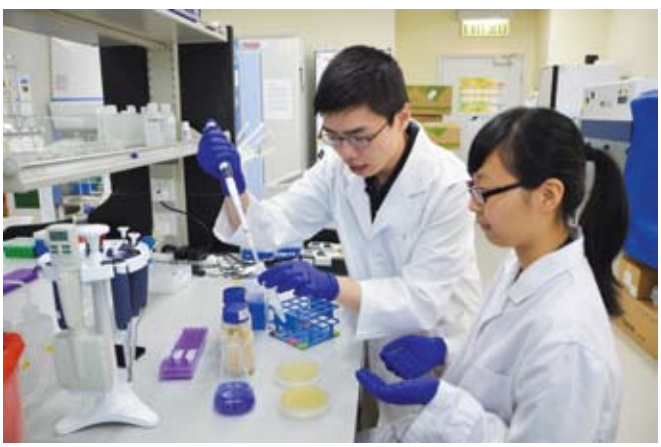
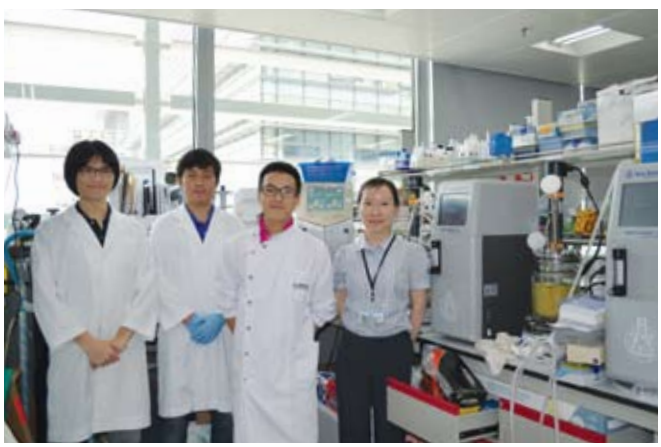
Ms. Yany Lo-Quiroz, Managing Director of WIT Holdings Limited, whose company has extensive experiences with waste collection in Hong Kong, recently pointed out that food waste collection in Hong Kong will take considerable coordination, efforts and experiences in order to make it a success. She mentioned that convincing the Hong Kong public to separate their waste at source into food/organic waste, recyclable materials and real garbage is still at its infancy. However, learning from other countries in Asia and North America, implementing a successful waste separation scheme is not impossible. For example, specially designed bags/containers can be provided to residents of large housing estates to be used to dispose food waste and these bags/containers are collected on a regular basis at specific sites within the housing estate. The sealed bags/containers can prevent odour and the collected food waste will be delivered to designated treatment facilities within a reasonable time for hygiene reasons. According to WIT Holdings Limited, trial programs are now underway at a few housing estates and it is would be interesting to see the results from these trial runs as well as the lessons that can be learned from them. Overall, in order to make waste separation at source a success, strong cooperation and participation from the public, government, industries, non-government organizations, and other concerned groups will be required.

In the long run, to ensure a sustainable society, zero food waste is the ultimate solution. However, food waste reduction will not happen overnight but will be a gradual process. In the meantime, developing treatment technology in combination with effective source separation schemes, as well as education that waste reduction and separation is a social responsibility will prevent food waste from ending up in landfills and ultimately allow Hong Kong to better manage its solid waste. We at SEE/CityU are continually working to develop new technologies to work towards this goal and we welcome collaboration with industries to upscale our laboratory results to commercially-viable operations.



Dr. Patrick Lee (Left) carried out research with a 3rd year undergraduate student (Li Kwan Ting) in his laboratory.



Dr. Carol Lin (Right 1) and her research team members.