Kitchen Waste Management: A Case Study from China

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Economic growth, urbanization, industrialization and population growth have led to generation of a considerable amount of solid waste across the world. Kitchen waste accounts for a large portion of collected solid waste in different countries. Deploying different methods to treat kitchen waste contributes to sustainable development. This paper presents real-world insights from a waste management corporation in China, i.e., Weifang Jinxinda bio-chemical Co., Ltd. Different treatment methods, process flow, and conversion rates from waste to a final product are discussed.

Keywords: waste management, solid waste, incineration, composting, anaerobic fermentation, landfill, anaerobic digestion, biodiesel, waste

INTRODUCTION

In the past decades, solid waste management has attracted a lot of attention due to rapid economic development and industrialization, and global urbanization (Suocheng et al., 2001, Xue et al., 2008). China's population and economy have significantly developed bringing about considerable amount of solid waste to be managed, from which approximately 60% is made up of kitchen waste (Zhang et al., 2010), accounting for 30 million tons of waste annually (Li et al., 2016). In Britain, approximately 15 million tons of food waste is generated annually (Salemdeeb et al., 2017), and that number is between 89 to 100 million tons for European Union (EU) (Monier et al., 2010).

The largest proportion of solid waste in China is food waste with high moisture content (Shahriari et al., 2013; Wang et al., 2019). Kitchen waste, which contains derivatives of a variety of food products, generates methane when it is landfilled (Wang et al., 2018), and methane has a greater global warming potential than carbon dioxide (Solomon et al., 2007). Lack of proper waste management systems have adverse environmental consequences such as water and soil contamination through leachate with adverse health implications for humans and animals (Zurbrugg, 2002).

There are different methods for utilizing kitchen waste such as incineration, landfilling, composting, and feeding kitchen waste to animals (Kiran et al., 2014; Kim and Oh, 2011; Salemdeeb et al., 2017). Anaerobic fermentation is another method to utilize and process kitchen waste (Dlabaja and Malaťák, 2013; Hřebíček et al. 2009; Zhang et al., 2007) with application in biogas plants.

Composting, landfilling, and incineration all generate greenhouse gases (Salemdeeb et al., 2017; Kim and Oh, 2011). Unlike incineration which is not the best method for treating moist biomass, Anaerobic

Digestion (AD) is an effective method to convert wet food waste to biogas with no pre-treatment (Appels et al., 2011). AD consists of processes that converts biomass to biogas (Evangelisti et al., 2014). One of the drawbacks of utilizing AD for processing kitchen waste is lack of efficient technology to dispose of biogas residues (Li et al., 2016).

According to food waste hierarchy (Papargyropoulou et al., 2014; zu Ermgassen et al., 2016), landfilling or disposal is the least favored method for handling food waste; however, it may be the only method for waste management in some areas (Hafid et al., 2017). The second least favored option is utilization of AD technology to recover energy from food waste. More preferred than AD for handling food waste is recycling of food waste by composting or feeding it to animals; however, utilizing composting technology to process food waste leads to methane production which is also one of the leading causes of the greenhouse effect (Sindhu et al., 2019). Redistributing food, and reducing food waste are the second best, and the best methods for handling food waste, respectively (Papargyropoulou et al., 2014; zu Ermgassen et al., 2016). In another study (Zhou et al., 2018), it is indicated that incineration provides a better environmental performance than landfill; however, it incurs high treatment costs for solid waste, and releases toxins such as dioxins (Li et al., 2016).

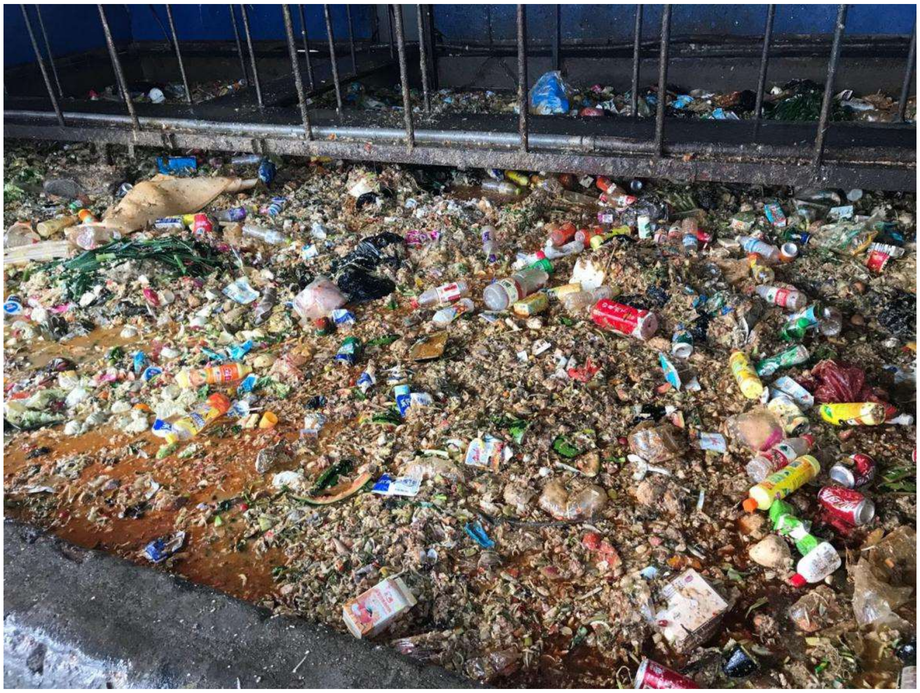
Although feeding kitchen waste to animals is one way to utilize this resource, there are concerns associated with harmful compounds generated in the frying process of food going back to the food chain through animal meat obtained from animals eating kitchen waste which contains those harmful compounds (Li et al., 2016). Furthermore, according to EU guidelines, it is illegal to feed most of food waste to animals in order to control transmission of food-and-mouth and African swine fever diseases (Salemdeeb et al., 2017). Regulated heat treatment, however, provides safe food waste to be utilized as animal feed (Garcia et al., 2005). Negative impacts of transmission of heavy metal to animals is another concern associated with feeding food waste to animals (Chen et al., 2014). The high salt content is another deterrent for using kitchen waste as fertilizer or animal feed (Yan et al., 2011).

FOOD WASTE MANAGEMENT IN WEIFANG CHINA

Environmental problems have become an obstacle to China's development. In July 2010, the general office of the state council of China issued a series of statements on strengthening the regulations for gutter oil and food waste management. In October 2010, the general office of China's national development and reform commission, the general office of housing and urban-rural development of China, China's ministry of environmental protection general office, and the general office of the ministry of agriculture jointly issued a notice on launching a pilot program in different cities in China for recycling of food waste. Weifang, China, has been designated as one of the pilot cities for implementation of food project treatment and resource utilization project.

Weifang Jinxinda Bio-chemical Co., Ltd. is one of the first corporations which independently designed and developed the technology and production process to treat food waste, and officially established Weifang city’s food waste treatment and resource utilization center in 2013. In order to ensure that the food waste collection and transportation are all controlled by Weifang Jinxinda Biochemical Co., Ltd. and can be properly regulated by the government, Weifang Jinxinda Bio-chemical Co., Ltd. invested in nearly 100 food waste collection vehicles. The food waste transfer vehicles meet the high standards and management requirements for business operations. Figure 1 shows the waste collected and waiting in the transfer station to be transported to Weifang Jinxinda Bio-chemical Co., Ltd.

FIGURE 1
COLLECTED FOOD WASTE IN THE WASTE TRANSFER STATION



As demonstrated, the food waste collected in Weifang city consists of different types of household waste including plastic bottles, plastic bags, and aluminum cans. Weifang Jinxinda Bio-chemical Co., Ltd. utilizes food waste pre-sorting process to extract food waste from the mixture of different types of household waste. Garbage pre-sorting plays a vital role in effectiveness of the subsequent steps for waste treatment. Figure 2 shows the process flow for different treatment methods as well as the final products.

The operational capacity of Weifang Jinxinda Bio-chemical Co., Ltd for food treatment was approximately 400 tonnes a day. In June 2020, after the completion of the second phase of the project of resource utilization and treatment of food waste in Weifang city, the company expanded its operational capacity to 1,200 tons of food waste every day. The cost of collecting and transporting food waste is mainly determined by the distance between the source of food waste and the processing plant. At present, the cost of food waste collection and transshipment is about $38.05 per ton, and the cost of food waste disposal is about $15.6 per ton. 80% of one ton of collected food. From one ton of food waste, 3% which equals approximately 30Kg, is extracted as waste oil through sebum separation process. After applying various treatment methods, biodiesel, glycerin, and vegetable asphalt (heavy oil) are produced as final products.

Biodiesel is a renewable energy, which does not contain sulphide and can effectively reduce the environmental pollution caused by petrochemical diesel. The biodiesel produced by Weifang Jinxinda Bio-chemical Co., Ltd, has reached the export standard and is being sold globally. The main problem is that the price of biodiesel is impacted by oil, and gutter oil prices on the international market. In the second half of 2019, the price of biodiesel reached $989 per ton, but in 2020, amid COVID-19 pandemic, the price of biodiesel dropped significantly due to the decline in international oil prices. Vegetable asphalt can be utilized as oil for large ships or to make waterproof materials (see Figure 3).

FIGURE 2
WEIFANG JINXINDA BIO-CHEMICAL CO., LTD FOOD WASTE MANAGEMENT SYSTEM

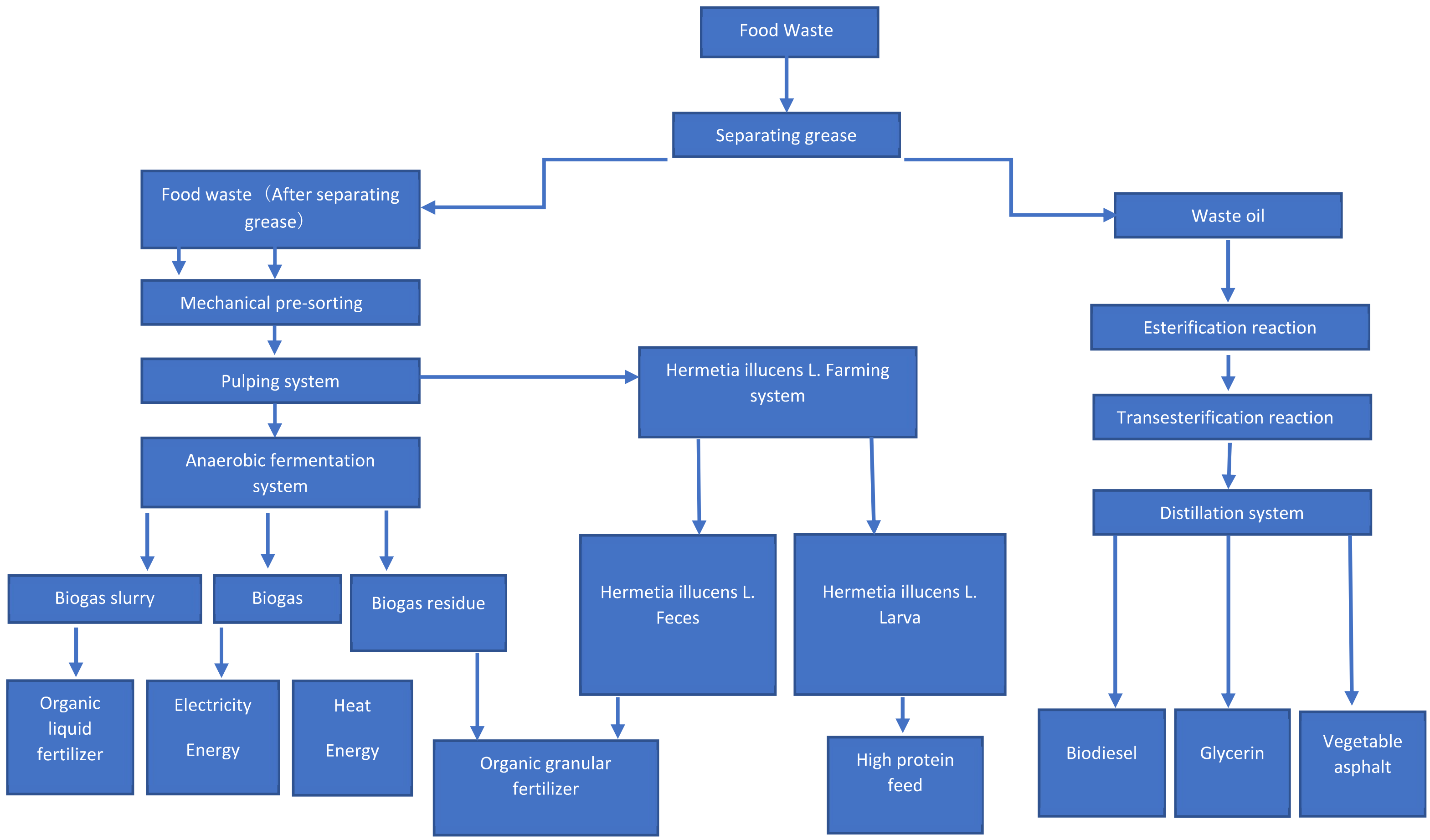


FIGURE 3
VEGETABLE ASPHALT (PHOTO FROM WEIFANG JINXINDA BIO-CHEMICAL CO., LTD)

Another kind of additional product is crude glycerin (see Figure 4). Crude glycerin has a variety of applications and can be converted into chemicals.

FIGURE 4
GLYCERIN PRODUCED BY WEIFANG JINXINDA BIO-CHEMICAL CO., LTD

After de-oiling the food waste using low-temperature anaerobic fermentation process, biogas, biogas slurry and biogas residue are obtained. Biogas is a clean fuel that can be used to generate electricity. Weifang Jinxinda Bio-chemical Co., Ltd. not only supplies the factory with the electricity generated by biogas but also sells the excess electricity to the local power grid. The heat generated by biogas can also be used in biodiesel production lines. After desalination of biogas slurry, organic liquid fertilizer with high organic matter can be obtained, which has been proven to increase the yield.

One ton of food waste can produce 820Kg of biogas slurry and 100kg of biogas residue. By anaerobic fermentation of 820kg of biogas slurry, 1,640 cubic meters of biogas can be produced, which can be used to generated 2,460 degrees of electricity. Pipes are used to supply electricity to the power grid generating revenue of $0.04 per degree. After fermentation, the 820Kg of biogas slurry can be converted into 800Kg of organic liquid fertilizer valued at $282 per ton. 100kg of biogas residue can be converted into 50Kg of organic granular fertilizer valued at $282 per ton.

Biogas residue is used to produce organic granular fertilizer. After being treated by the food waste pulping system, the food waste can also be fed to the Hermetia illucens L (Hermetia illucens L. is a saprotic member of the hydrotabanidae family that feeds on livestock waste and household waste and is used to produce high-value animal protein feeds.). It has been introduced into China in recent years and is now widely distributed in Guizhou, Guangxi, Guangdong, Shanghai, Yunnan, Taiwan, Hunan, Hubei among others. In just 14 days, the larvae form of Hermetia illucens L. stops growing and begin to morph into adults. Adults do not carry bacteria and can only live for about 10 days. They are inert and easy to control. In the metamorphosis stage, the larvae can be dried and ground to make rich protein animal feed. It can also be used for raising birds, fish, livestock and other animals. In addition, the excrement of insects is also a high-quality organic fertilizer which can be mixed with the organic fertilizer produced by biogas residue to improve the fertility of organic fertilizer (the production line is still in the development phase).

CONCLUSION

A high portion of generated solid waste in different countries consists of kitchen waste. This paper provides real-world insights from a waste management facility in China on kitchen waste management. Variety of final products which can be produced by treating kitchen waste, different treatment methods, process flow, and conversion rates from waste to a final product are discussed.

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