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Home Composting Method for the Treatment Technologies of Food Waste: A Review

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Abstract. The increase in environmental pollution is largely reflected by industrial activities, urbanization and population development. Due to these activities, it has produced millions of tons of food waste every day. Food waste has become a serious problem in the world as most countries are also concerned about the challenge of managing food waste. Studies suggested that composting is a better method to control and reduce the amount of food waste as it is easy to apply and can be harvested in a short period. Composting also ensures a promising return in prolonging the life span of landfills, as well as reduces the leakage of leachate into groundwater.

1. Introduction

In recent years, the boom and bust of local economic growth have given a significant benefit to the country. Nevertheless, industrialization, urbanization and population growth have led to a rapid increase in pollution and waste generations especially food waste wherein landfills could not be tolerated for the coming years. The increasing amount of food waste in recent years has brought many environmental issues where it affects the nation's solid waste management framework. Around the world, food waste has become a global issue where all countries have to face the same problem with excessive food waste which is not suitable to be disposed of by the traditional method like incineration and landfilling.

In Malaysia, the movement restriction order (MCO) during the COVID-19 pandemic was a contributor to unplanned food waste, which posed threats to food security, food health, economics and environmental sustainability. Some factors in the household activities may affect the generation of food waste such as excessive shopping, storage and housing management problems, as well as other psycho-social factors such as lifestyle, eating habits and lack of cooking skills during the MCO period [1]. Moreover, peoples are more accustomed to the habit of wasting their own food or buying it often beyond their needs. According to the National Solid Waste Management (NSWM) in the Survey of



Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling in Malaysia 2011-2012, waste composition as generated, discarded and disposed from household can be classified according to paper, diaper, plastic, food waste and others waste [2]. From the figure 1, it is clearly showed that food waste is the highest waste generated from household activities with 45% of waste composition while others made up with 9% of paper, 12% of diaper, 13% of plastic and 22% of others waste. According to NSWMM, food waste can be described resulting from the storing, preparation, cooking, handling or consumption of food such as vegetable peelings & trimmings, including cooked vegetables, kitchen waste that contains or is potentially contaminated with meat/meat products [2].

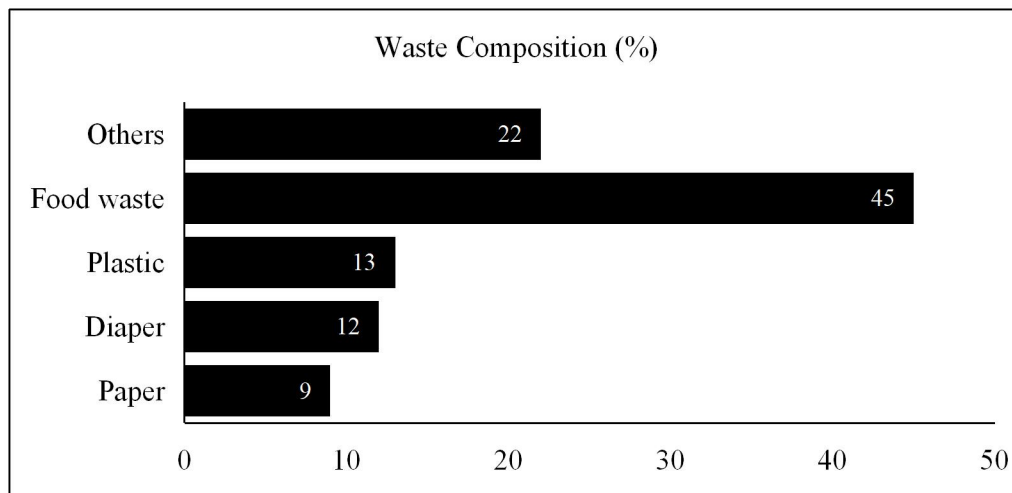


Figure 1. Waste composition from household activities [2].

The main issue that arises from food waste generation is how it should be disposed. According to table 1, a few treatment technologies can apply to dispose food waste such as animal feed, composting, incineration, landfill, anaerobic digestion, heat recovery, food waste disposer and recycling [3–7]. According to Trabold & Nair [4], feeding food waste to animals potentially transferred disease. Besides, incineration method is benefited in terms of energy production, however this method requires high operating and maintenance costs, as well as potentially emit polluted gases, carry ashes, heavy metals and other organic and inorganic compounds [4]. Incineration may also cause acid rain and eutrophication due to the emission of nitrogen dioxide [5]. According to the waste hierarchy, landfill is considered least environmentally sustainable option due to the greater emission of GHG and requires large area to be executed [3–5, 7]. Meanwhile, composting is a simple technique and sustainable method if operates with proper handling.

Table 1. Type of treatment technologies for food waste.

Researchers	Treatment technologies
[3]	<ol style="list-style-type: none"> 1. Composting 2. Incineration and landfill 3. Recycling 4. Heat recovery
[4]	<ol style="list-style-type: none"> 1. Animal feed 2. Composting 3. Incineration 4. landfill
[5]	<ol style="list-style-type: none"> 1. Anaerobic digestion 2. Landfill 3. Incineration 4. Composting 5. Heat-moisture reaction
[6]	<ol style="list-style-type: none"> 1. Anaerobic digestion
[7]	<ol style="list-style-type: none"> 1. Landfill 2. Composting 3. Food waste disposer 4. Anaerobic digestion 5. Mixed materials recycling facility

In Malaysia, methods of disposal of food waste at landfills have raised concerns over the greenhouse effect due to methane releases during the decomposition of organic materials. The emission of GHGs is not only generated from machinery and transport vehicles, but also from the breakdown or decomposition of food waste. According to the report by the Ministry of Water, Land and Natural Resources (KeTSA) in conjunction with the United Nations Framework Convention on Climate Change (UNFCCC), waste management sector accounts for 12% of total GHG emissions in Malaysia [8]. United States Environmental Protection Agency (USEPA) reported that landfill gas is composed of roughly 50% of methane as the primary component of natural gases, 50% carbon dioxide (CO₂) and small amount of non-methane organic compounds [9]. Methane is 28 to 36 times more potent GHG than CO₂ at trapping heat in atmosphere during a time frame of 100 years [9].

Out of all proposed treatment technologies, local government has come out a solution, whereby the nation is encouraged to carry out composting at household level, as to make practical, cost-effective and sustainable solid waste management an explicit goal to be met by 2020.

2. Composting as a Treatment Technologies

According to several researchers, composting can be defined as a natural process that results in the succession of microbial that deteriorates and stabilizes waste-present organic matter [10]. Composting also is a food waste management technique by transforming organic wastes into organic amendments in aerobic conditions [11]. Besides that, composting is an advantageous technology to stabilize and produce organic fertilizer which is good to be used as a soil conditioner [12].

Composting has become a crucial method for treating food waste while creating a viable product in less-developed countries. As proposed by Rastogi et al., composting method can replace landfilling method which previously as a secondary waste treatment method depending on the composition of the

waste materials [10]. Rastogi et al., also stated that composting is the technology method that is more preferred, economically sustainable and more efficient when properly handled [10]. Ballardo et al., also proposed environmental awareness can be increased through efficient home composting method [13]. The option to separate household food waste from the source directly to home composting was pointed out as a part of the integrated and hierarchical waste management strategy on the local level, as a preventive action to reduce household waste generation.

Home composting is preferred because of the lowest impact environmental technology, reducing transportation costs and emit lower gas emissions [14]. In fact, Barenna et al., argued that home composting is technically safe and efficient to produce stable and matured compost in contrast with industrial-scale compost [15].

There are a few factors affecting the composting process such as C/N ratio, temperature, pH, moisture content (MC), total carbon (C), nitrogen (N) and sulphur (S), total nitrogen (TN), aeration, particle size and germination index (GI) [10]–[12], [16]. Besides above factors, effective microbes (EM) were introduced in the composting bed in order to increase the efficacy of composting process. EM such as *Bacillus thuringiensis* (Bt) [13], *Corynebacterium*, *Bacillus*, *Luteimonas* and *Nonomuraea* [12] were introduced to modified the compost quality as well as affect the humification degree [10]. Microbial additives are found to be highly efficient during composting, thereby leading to a better rate of waste digestion in the production of specific enzymes. Meanwhile, Zhong et al., determined that the modulation of functional microbes in composting could minimize the composting time and increase the consistency of compost [12].

3. Principle of Composting Process

For a better understanding, principle or anatomy during composting process should be considered. Composting process required major nutrients such as C and N as energy sources along with oxygen and water in order for the microbes to carry out the decomposition of organic matter [10]. According to table 2, composting process may work according to different anatomy as discussing thoroughly by several researchers [10]–[12]. There are four important stages that occurred during composting process which are initial phase (day 0 to 3), thermophilic phase (days 1 to 4), cooling phase (days 4 to 22) and maturation or mesophilic phase (days 12 – 60). After 60 days, mature compost can be harvested and ready to be used as organic fertilizers.

During initial phases, there are few reactions occurred such as degradation, mineralization and accumulation process. According to Rastogi et al., simple compounds such as sugars, amino acids are degraded with the aid of mesophilic bacteria and fungi and thus raise temperatures quickly [10]. The mineralization of simple organic compounds such as sugar by microbial communities has producing several pollutants gases such as CO₂, ammonia (NH₃), organic acids and heat [11], [16]. Also, temperature was recorded rose during this stage.

In the next stage, accumulation and degradation of organic nitrogen take place. Thermophilic microbes degrade the organic matter such as fats, cellulose, hemicellulose and lignin [10], [16]. Then, the accumulation of ammonium (NH₄⁺) has increased the pH of the compost as a result of N degradation [17]. As recorded, the average of pH can be up to 8.76 in thermophilic phase [17]. At days 4, the total of NH₄⁺ rose due to organic nitrogen degradation [12]. During this stage, temperature reaches maximum which above 55°C allowing to kill pathogens [11].

In the third stage, cooling phase occurred followed by maturation of mesophilic phase. Reaction such as nitrification, volatilization and degradation of organic matter takes place during mesophilic phase. Approximately starting from days 12, the temperature slowly reduced due to lessening of microbial activity stemming from a reduction of biodegradable compounds [11]. The nitrate (NO₃⁻) was recorded appeared and increased until days 60 due to the biological nitrification [12]. As a result of volatilization and nitrification of NH₃ at cooling and maturation phase, the pH is gradually

decreased [17]. GI gradually increased around days 37 indicating that the phytotoxicity is disappeared and compost matured [12].

Table 2. Anatomy of composting process [10-12, 16].

Days	Phase	Reaction
0	Initial phase	<ul style="list-style-type: none"> • Degradation • Mineralization
1		<ul style="list-style-type: none"> • Accumulation
2		
3	Thermophilic phase	
4		<ul style="list-style-type: none"> • Degradation of organic nitrogen
5-11	Cooling phase	
12		<ul style="list-style-type: none"> • Degradation
13-22	Maturation or mesophilic phase	
23		<ul style="list-style-type: none"> • Nitrification
27		<ul style="list-style-type: none"> • Volatilization
28-36		
37		<ul style="list-style-type: none"> • Degradation of organic matter
38 - 60		
After 60 days		<ul style="list-style-type: none"> • Degradation • Water evaporation

4. Conclusions

As a conclusion, food waste from household activities can be disposed through home composting method. Besides simple processing techniques, home composting offers an alternative method of disposing of organic waste with commercialized end products such as organic fertilizers or soil conditioners, natural pesticides and biomass. Since landfill is the prime method to get rid of waste, reducing the waste at its source through composting method is a fundamental approach for conserving the environment as well as prolong the lifespan of landfills. It is undeniable that nurturing the next generation with positive good practices elevate the quality of living for citizens. Thus, implementing good values and raising awareness in teenagers at a young age by conducting home composting with families have given opportunities for the next generation to secure a better living through practicing sustainable living.

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