JOURNAL OF STRUCTURAL MONITORING AND BUILT ENVIRONMENT
e-ISSN: 2821-3432

JSMBE

Vol. 4 No. 1 (2024) 67-73
https://publisher.uthm.edu.my/ojs/index.php/jsmbe

Comparison Between Conventional Method and Cradle-to-Cradle Method of Waste Management Method

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DOI: https://doi.org/10.30880/jsmbe.2024.04.01.009

Article Info

Received: 20 February 2024
Accepted: 27 May 2024
Available online: 30 June 2024

Keywords

Sustainable waste management, cradle-to-cradle (C2C) method, black soldier fly

Abstract

Population growth, rapid development and Covid-19 outbreak contributes to the waste generation. Sustainable waste management procedures limit untreated debris disposal where this renewable method will benefit to the environment. Main objective of this study is to determine the best method of waste management that can be proposed to apply in Malaysia. Conventional method and cradle-to-cradle (C2C) method have advantages also disadvantages that will be considered to provide an overall comparison. This study's methodology includes reviewing previous studies, obtaining data from project conducted at Solid Waste Research Center (SWRC), UTHM and afterwards analyzing the findings. Three elements such as environmental impact, process in producing new product and cost expenditures also considered to be discussed. This research concludes based on the results in comparison, Malaysia should practice the C2C waste management method as it is the best waste management technique due to the waste prevention at the end of any product's life cycle as a key.

1. Introduction

Humans will inescapably produce garbage in daily life and much more waste produced during the Covid-19 outbreak. Increasing of population growth also contributing to the waste generation indicating the production of waste will be increased. Thus, effective waste management is critical to ensuring that the environment is preserved for a long period of time aside from stopping landfill operation so that the site can be repurposed for new development [1]. Sustainable waste management procedures are employed to limit the amount of untreated garbage that is disposed. C2C method and conventional method have been created to solve this issue. Both actions are based on the idea that waste is the material used in the creation of a new product. Such production can be helpful and employed in a variety of industries, including construction, agriculture, transportation, and others [2]. Both strategies have their own credibility when it comes to the creation of new products. The aim of this research is to compare the conventional method with project had applied C2C concept. Data on conventional method were collected through literature review while data on C2C method will be collected at fieldwork project. Thus, these studies conducted will produced a comparison of both method as accomplishment, to proposed the best method that can be applied in waste management method in Malaysia.

2. Materials and Methods

Waste is something that is undesirable, no longer needed and abandoned. The amount of trash produced affects the environment and humanity. Municipal solid trash, industrial waste, agricultural waste, and hazardous waste are four forms of garbage. In these categories, not all garbage can be discarded through landfill disposal since part

of it is non-degradable and can be recycled. Furthermore, waste management is collecting, treating, and dumping of material that is abandoned since it has fulfilled its purpose or is no longer necessary [3]. As part of the zero-waste challenge, Solid Waste System Support promotes consumption reduction, diversion, reuse, repair, and sustainable purchasing.

Prohibiting undesirable items like plastic bags, unnecessary packaging and promoting alternatives such as recyclable or biodegradable take-out food packaging and reusable transportation packaging considered as the most conspicuous measures aimed at accomplishing the zero-waste goal [4]. Effective waste management as a key to preventing illicit waste dumping. China, India, and Singapore have provided impartial waste management overviews. Waste management studies in Malaysia are also being considered in order to make future improvements.

China is an advanced country with many innovative sustainable technologies implemented. China's residents are also recognized for their ancient food and medicine. China uses cockroaches in medicine because it works faster than other drugs. Traditional Chinese Medicine used periplaneta americana cockroach converts into powder for tissue healing, immunological improvement, and blood circulation stimulation. It also has anticancer, liver preservation, anti-inflammatory, and tissue healing application [5]. Besides, India produces synthesis gas from waste using plasma gasification. Gasification converts coal or biomass into gas [6]. It could improve recycling technologies [7] and it can do so by improving recycling, allowing resources that are currently unrecyclable to be used in the economy. In addition, Singapore aims to become a zero-waste nation as the country faces the same global issue of where to dispose of its growing amounts of rubbish. Singapore's only sanitary landfill, Semakau Landfill, 8 km from the mainland. Singapore manages its waste through an incinerator plant that produces ash and bottom ash [8]. Harmful heavy metal sources are eliminated by pre-sorting municipal solid waste before mass fire incineration. However, Malaysia's waste management is still poor because most waste is buried. Biological, chemical, and physical degrading processes in landfills that accept a variety of wastes can cause leachate and gas emissions [9]. Anaerobic digestion method is used in waste management in Malaysia due to the a cost-effective and environmentally friendly alternative to organic waste. These options can save money on energy costs and make money by selling biogas or electricity. C2C is the process of designing and manufacturing recyclable products. Imitating nature's cycle by recycling or returning everything to the earth as a safe, nontoxic, biodegradable nutrient. C2C divides material processes into biological and technological cycles. [10]. The C2C approach reduces waste and promotes sustainability when creating new products for example, produce thinner with sustainable paint waste. Flushing a painting unit's pipes and thinner receiver with fresh thinner is also common.

Manufacturers of automobile firms must frequently switch production lines between colours to make cars in variety of colours. Thus, the effluent from flushing the painting facility is waste paint and it can be recovered to produced thinner [11]. By 2030, half the world's population may face water scarcity, a resource needed for mining and the production of steel, concrete, plastics and resins, ceramics, and coatings, not to mention lumber. China's secondary steel production can improve the steel industry's sustainability in many ways, including ore, water, land, and energy consumption, as well as greenhouse gas and pollutant emissions [12]. The net supply of domestic scrap is governed by metal consumption while the supply of fresh scrap is determined by production and fabrication efficiency. C2C practices help provide massive steel resources in a few years for construction and development.

Conventional waste management is primarily concerned with waste collection, treatment by composting and incineration, and disposal to the landfills [13]. A linear model of production results in high material and energy consumption and waste. As long as this trend continues unchecked, nonrenewable natural resources will continue to diminish and global natural resources will be depleted [14]. Concept of conventional method had implemented in transportation. Polymers are broken down using many different processes to produce oil, gasoline, syngas, monomers, and other by-products. A form of thermochemical recycling where heating occurs without oxygen is called pyrolysis define as extracting oil from discarded polymers [15].

Waste-to-wealth mechanisms have been developed to recycle and reuse waste. Plastic waste-to-fuel is one such evolution. Many studies have been done on catalytic and non-catalytic pyrolysis of plastic waste. Furthermore, anaerobic digestion (AD) for food waste resource management has gained interest in recent years due to its ability to generate clean energy with low carbon emissions and to be used in fertilisation operations [16]. Digestate biofertilizer is used to promote agricultural food supply and soil development. Clean digestate can be composted to make fertiliser and soil stabiliser. Depending on its quality, digestate can be composted directly or with other biowaste. Food waste anaerobic digestion at different temperatures affects soil microbial populations and soil fertility [17].

Both methods have advantages and disadvantages that will be considered to provide an overall comparison. Furthermore, numerous obstacles must be solved to reach the goal of minimizing the problem of inefficient waste management.

Table 1 *Projects applied C2C concept*

Item	Label	Type of waste	Description
1	Healthcare Industries	Cockroaches	Periplaneta americana cockroach into powder as medicine
2	Bioenergy	Solid waste	Produces gas from solid waste such as coal and biomass
3	Bioenergy	Organic municipal solid waste	Produced biogas through anaerobic digestion
4	Automotive Industries	Hazardous waste	Recovered waste paint to produce thinner
5	Construction Industries	Solid waste	Secondary steel production

3. Methods

Literature review focus to provide discussion to support the study and it also has the goals of describing the work to develop new theoretical framework and explore underlying assumptions. Based on identification on C2C method, few aspects contributing to the successfulness of this approach can be determined. Review from many resources like journals, articles, thesis, webpage, books are used to gather the information related to the topic without concentrating solely on approaches that integrated in Malaysia but also explore at the effectiveness techniques used by other countries which more benefits to the nature and humankind. Thus, understanding from case study will be carried out a comparison between conventional method and C2C method used in waste management. This strategy is ideal for clarifying and explaining the findings of the study.
Besides, fieldwork is conducted at Solid Research Center (SWRC), UTHM to make observations on the project carried out. Black soldier fly larvae (BSFL) are used in the process of decomposing food waste into organic fertilizer. The project was carried out approximately three weeks to investigate the cycle of BSFL, factor affecting the composting process and expenses during the implementation.

4. Results and Discussions

4.1 Literature Review

Through studies from literature review, 5 themes were found out that had applied concept of C2C in waste management. By referring to Table 1, healthcare industries in China used cockroaches in medicine. Cockroaches are notoriously unclean. Despite heavy demand from hospitals or clinics, Periplaneta americana cockroaches can be process into powder to produce medicine. Hence, medical firm can provide enough remedies without worrying about shortage of resources since C2C strategy utilised circular economy upcycling concept. Second and third theme also implement the C2C concept in the production of bioenergy. Process of solid waste and organic municipal solid waste to produce gas or biogas resulting to the reduction of CO2 emissions more than natural gas. For the next theme is hazardous waste. As example, paint waste can be turned into thinner. Regardless of being toxic, composite sustainability index is used to design ecologically friendly chemical production methods in thinner manufacturing processes. Lastly, the building and construction sector adopts the C2C idea. Steel scrap may be recycled into secondary steel, making the building industry greener. When demolishing historic structures, a lot of solid trash is generated and deposited in landfills. So, China's sophisticated technology extracts ore and scrap to make secondary steel to reduce C&D waste. This is smart for development and trash management.

4.2 Fieldwork

A C2C project have been conducted using Black Soldier Fly (BSF) as an approach to lessen the food waste produced. BSF is a very intriguing contender for organic waste conversion.

The egg in Figure 1 begins the BSF life cycle and ends the previous stage. These eggs are placed in crevices or on surfaces near decomposing substances like dung or compost and hatch in four days. Freshly born larvae are 1 millimetre long and grow to 25 millimetres. The larvae can adapt to different diets, allowing them to eat a variety of organic material. The larvae stage lasts 18 to 36 days, whereas the prepupae stage lasts 7 days. Low temperature or lack of food can extend the larvae stage by months. Pupae last 1-2 weeks. Adults can live 47 to 73 days with water and food or 8 to 10 days on larval fat stores with water.

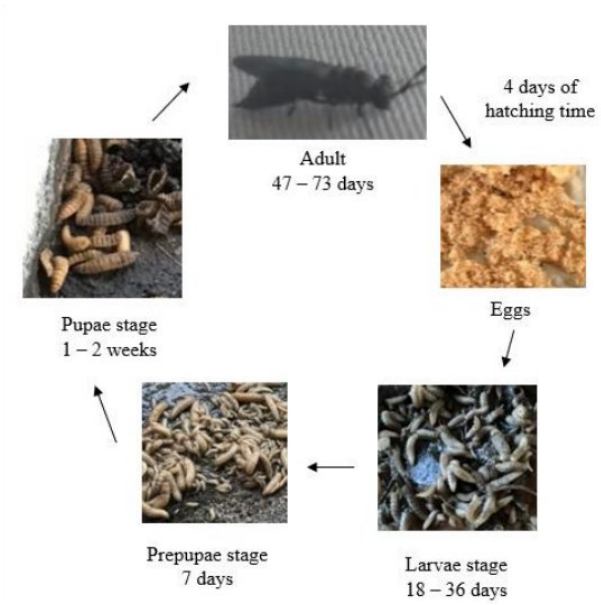

Fig. 1 *Black soldier fly (BSF) cycle*

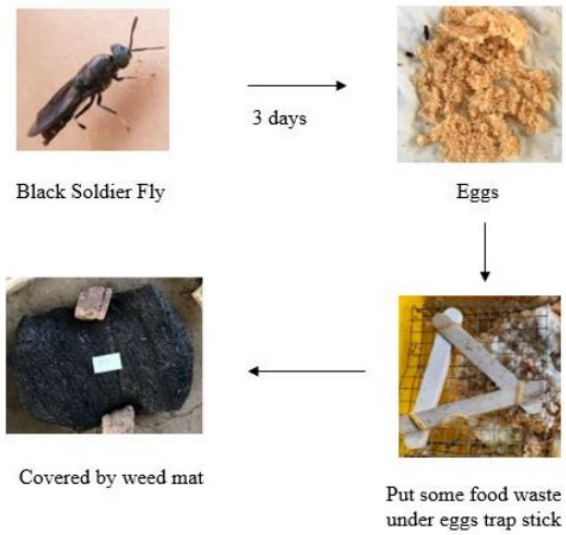

Fig. 2 *Cycle of egg hatching*

Black Soldier Fly (BSF) was placed in a breeding cage during fieldwork at SWRC. A tray with triangle sticks is an egg trap as in Figure 2. Unhatched eggs on egg trap sticks were collected after 3 days and deposited in a tray with 1 inch of food waste then covered with weed mat for 7 days before composting. Next, eggs or larvae were transferred to a baby bio-pond. Food waste of 1 to 2 inches thick is prepared. The larvae should be placed on food trash so they can eat for 3 days and covered with weed mat. Other insects will be collected to prevent product damage. After 3 days, move larvae to a bio-pond with food waste. Food waste from restaurants and household of Taman Pura Kencana and Taman Universiti is collected to be used in production of frass. Approximately 100kg of food waste was thrown into the bio-pond and spread flat. Using a small shovel, the larvae were put on top of the rubbish. Cover the bio-pond for 3 days to help larvae grow quickly and prevent pests.

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Fig. 3 *Prepupae try to leave the bio-pond*

Then, prepupae trying to leave the bio-pond as shown in Figure 3. Next, pupae were collected when they fell into the black woven cloth and transferred to the breeding cage. Seven to nine days later, the prepupae died. As solid waste dries, larvae exit the bio-pond. The larvae were sieved to remove contaminants. Larvae won't fall through the sieve, but frass will. Frass must be dried for 3-5 days before being weight.

5. Results and Discussions

Many regions employ conventional methods. It emphasizes activities that affect integrated waste management techniques. Since 2010, C2C waste management has been established. The C2C concept recycles waste without polluting the environment. Both approaches recycle to reduce waste. Conventional waste disposal through landfill can't handle daily trash disposal. In Singapore, landfill trash is incinerated to produce ash and bottom ash. The process emits harmful gases as nitrous oxide, carbon dioxide, etc. at high temperatures. Meanwhile project conducted at SWRC, frass production from food waste was only used black soldier fly (BSF). Moreover, organic fertilizer processing only creates odour at the project site, while landfill waste emits an unpleasant stench that bothers neighbours. Toxic substances in trash leach into the ground, degrading land. If the landfill is ever closed and repurposed, considerable pretreatment should be done first. Frass production is conducted on a bio-pond which does not affect the soil or surrounding region. Fractures and material dispersion are prevented. To eliminate waste at high temperatures, the requisite apparatus and technologies must be developed. Incinerators produced ash and bottom ash.

Frass manufacturing at the project site does not require modern technology because BSF degrades and dries food waste naturally. Hence, 0.40kg of organic fertilizer is produced from the project conducted in 18 days. In the typical approach, more money is set aside. Operating an incinerator cost between RM500 million and RM800 million annually. Frass production only used RM52,800 per year for transportation, operation, and maintenance.

Fig. 4 *Organic fertilizer*

Table 2 *Comparison of conventional method and C2C method*

Aspects	Conventional method	C2C method
Definition	Concerned with waste collection, treatment by composting and incineration, and disposal to the landfills	Process of designing and manufacturing products of any types in such a way that they can be recycled at the end of their useful life
Description	Many landfills area is still operating as a place for garbage dumping	Enhance the sustainability performance
Environmental Impact	Releasing hazardous gases throughout the procedure	Sustainable practices can help to reach the goal of "zero waste"
Process	Demands modern systems or machinery	Require regular inspections to ensure no pests or insects are present
Cost	Cost of incinerator for 800 to 100 tons of MSW in range of RM500 to RM800 million per day	Transportation cost require RM10 000 per year Operation and maintenance expense of RM42 800 per year

6. Results and Discussions

This research analyzes conventional method and C2C method in waste management. Waste management difficulties are largely caused by people's behaviour. This research could be utilised to prevent the problem from worsening. A literature review found C2C waste management projects approach results in new products produce from variety of waste. Previous studies have led to the discovery of a number of projects that comply with the C2C concept, including: (1) Extracting cockroach structures for medicine; (2) Generating biogas from solid waste as a bioenergy product; (3) Converting organic municipal solid waste into bioenergy; (4) Recovering waste paint for thinner; (5) Secondary steel production from steel scrap. Zero waste requires advanced ideas and technology for this strategy. Conventional and C2C method have same objectives to recycle waste follow the different process of each method. Both measures have different applications. This comparison considers environmental impact, production process, and cost. C2C has a substantial, positive impact compared to conventional methods. C2C waste management may be applied in Malaysia to improve environmental quality and the economy.

Acknowledgement

The authors would also like to thank the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

References

[1] Benson, N. U., Bassey, D. E., & Palanisami, T. (2021). COVID pollution: impact of COVID19 pandemic on global plastic waste footprint. Heliyon, 7(2). https://doi.org/10.1016/j.heliyon.2021.e06343
[2] Kumar Lohchab, R. (2018). Solid and Hazardous Waste Management. https://www.researchgate.net/publication/326658092_Solid_and_Hazardous_Waste_Manage
[3] Nathanson, Jerry A. (2020) "solid-waste management". Encyclopedia Britannica, https://www.britannica.com/technology/solid-waste-management.

[4] Kenawy, S. H., & Khalil, A. M. (2021). Reclaiming waste rubber for a green environment. In Biointerface Research in Applied Chemistry (Vol. 11, Issue 1, pp. 8413–8423). AMG Transcend Association. https://doi.org/10.33263/BRIAC111.84138423
[5] Zeng, C., Liao, Q., Hu, Y., Shen, Y., Geng, F., & Chen, L. (2019). The Role of Periplaneta americana (Blattodea: Blattidae) in Modern Versus Traditional Chinese Medicine. In Journal of Medical Entomology (Vol. 56, Issue 6, pp. 1522–1526). Oxford University Press. https://doi.org/10.1093/jme/tjz081
[6] Rajasekhar, M., Rao, N. V., Rao, G. C., Priyadarshini, G., & Kumar, N. J. (2015). Energy Generation from Municipal Solid Waste by Innovative Technologies – Plasma Gasification. Procedia Materials Science, 10, 513–518. https://doi.org/10.1016/j.mspro.2015.06.094
[7] Homolka, Z. A. (2018). Treatment of Plastic Wastes using Plasma Gasification Treatment of Plastic Wastes using Plasma Gasification Technology Technology. https://digitalcommons.unl.edu/envstudtheses
[8] Kerdlap, P., Low, J. S. C., & Ramakrishna, S. (2019). Zero waste manufacturing: A framework and review of technology, research, and implementation barriers for enabling a circular economy transition in Singapore. Resources, Conservation and Recycling, 151. https://doi.org/10.1016/j.resconrec.2019.104438
[9] Ismail, S. (2013). The challenge of future landfill: A case study of Malaysia. Journal of Toxicology and Environmental Health Sciences, 5(6), 86–96. https://doi.org/10.5897/jtehs12.058
[10] Woon, K. S., Phuang, Z. X., Lin, Z., & Lee, C. T. (2021). A novel food waste management framework combining optical sorting system and anaerobic digestion: A case study in Malaysia. Energy, 232. https://doi.org/10.1016/j.energy.2021.121094
[11] Ordouei, M. H., & Elkamel, A. (2017). New composite sustainability indices for Cradle-toCradle process design: Case study on thinner recovery from waste paint in auto industries. Journal of Cleaner Production, 166, 253–262. https://doi.org/10.1016/j.jclepro.2017.07.247
[12] Wang, P., Jiang, Z., Geng, X., Hao, S., & Zhang, X. (2014). Quantification of Chinese steel cycle flow: Historical status and future options. Resources, Conservation and Recycling, 87, 191–199. https://doi.org/10.1016/j.resconrec.2014.04.003
[13] Shanghai Manual-A Guide for Sustainable Urban Development in the 21st Century CHAPTER 5-MUNICIPAL SOLID WASTE MANAGEMENT: TURNING WASTE INTO RESOURCES. (2010). www.go.worldbank.org/2H0VMO7ZG0 Author 1 et al., Recent Trends in Civil Engineering and Built Environment Vol. 3 No. 3 (2022) p. 1-59
[14] Ajani, I. A., & Kunlere, I. O. (2019). Implementation of the Extended Producer Responsibility (EPR) Policy in Nigeria: Towards Sustainable Business Practice. In Nigerian Journal of Environment and Health (Vol. 2). https://www.researchgate.net/publication/341565113
[15] Bridjesh, P., Periyasamy, P., Krishna Chaitanya, A. V., & Geetha, N. K. (2018). MEA and DEE as additives on diesel engine using waste plastic oil diesel blends. Sustainable Environment Research, 28(3), 142–147. https://doi.org/10.1016/j.serj.2018.01.001
[16] Jin, C., Sun, S., Yang, D., Sheng, W., Ma, Y., He, W., & Li, G. (2021). Anaerobic digestion: An alternative resource treatment option for food waste in China. In Science of the Total Environment (Vol. 779). Elsevier B.V. https://doi.org/10.1016/j.scitotenv.2021.146397
[17] Cheong, J. C., Lee, J. T. E., Lim, J. W., Song, S., Tan, J. K. N., Chiam, Z. Y., Yap, K. Y., Lim, E. Y., Zhang, J., Tan, H. T. W., & Tong, Y. W. (2020). Closing the food waste loop: Food waste anaerobic digestate as fertilizer for the cultivation of the leafy vegetable, xiao bai cai (Brassica rapa). Science of the Total Environment, 715. https://doi.org/10.1016/j.scitotenv.2020.136789