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The Challenges in Application of 'Cradle-to-Cradle' Concept in Waste Management

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Abstract: The concept of 'Cradle-to-Cradle' (C2C) was an innovative designed framework to achieve positive environmental impacts by improving the quality of products and services. C2C in waste management was one of the alternative techniques to avoid the waste and developed newer production and processing techniques that could be used for other activities in the future. The objectives of this study were to identify the challenges and proposed solutions to address them in the application of the concept in waste management. There are 13 challenges that were determined by gathering the information from the literature review and using it to design the questionnaire. The quantitative data will be collected by using the Likert Scale. The Taro Yamane formula was used to determine sample size for a finite population, and Cronbach's Alpha method was used to determine the reliability and acceptance of the analysis. To analyse the data from the questionnaire, Principal Component Analysis (PCA) adopted from SPSS software was conducted to reduce and minimised information loss. From the PCA result, the critical challenges of the implementation of the C2C concept in waste management were determined according to principal components 1, 2 and 3, which have eigenvalues greater than 1 and were used for further analysis. Therefore, there are five critical challenges that were determined, which are: (1) the attitude and culture of Malaysians; (2) the level of education and exposure to the C2C concept; (3) the lack of technical expertise in operating and applying the C2C concept; (4) the acts and regulations related to waste management being implemented well and suitable; and (5) excuses from industries to implement the C2C concept. Thus, five critical challenges in the application of the C2C concept have been identified, and solutions for applying this concept have been determined that can help in the implementation of this concept in Malaysia.

Keywords: waste management, Cradle-to-Cradle, challenges

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1. Introduction

The purposed of this study was to identify the challenges in the application of 'Cradle-to-Cradle' concept in waste management and proposed solutions to the challenges that have been faced. The term 'Cradle-to-Cradle' (C2C) was found by Walter R. Stahel in the 1970's as a sustainable alternative to the conventional 'Cradle-to-Grave' within the make-use-waste approach of linear economy [1]. 'Cradle-to-Cradle' one of the alternative techniques for avoiding waste and developing newer production and processing techniques that can be used for other activities in the future. These concepts are not only environmentally friendly but also very economical. Malaysia is a developing country and is ranked as the world's 22nd most competitive economy [2]. Hazardous wastes are unavoidable in a country that engages in a variety of industrial activities such as manufacturing, construction, agriculture, mining, and quarrying. Hazardous waste was defined as scheduled waste in Malaysia [2]. Waste management was a critical subject related to a country's economic status and the lifestyle of its people. Solid waste management was defined as the control of solid waste generation, storage, collection, transfer, transport, processing, and disposal [3, 4]. Despite Malaysia's rapid economic development, solid waste management is subpar [3]. The outcomes from this study will not just give benefits to society but also be good for the environment, which means avoiding and reducing any pollution. The greater production of waste and proper waste management should be practised. Therefore, this study will help to establish the challenges in the application of the C2C concept in waste management.

The study goals is to identify the challenges in the application of 'Cradle-to-Cradle' concept in waste management and proposed solutions for the challenges in the application of the C2C concept. A survey has been conducted in order to determine the challenges of the C2C concept. Thus, a better understanding will be achieved as the survey comes from various types of backgrounds and perspectives. The outcome by gathering information from the literature review, there were 13 challenges in the application of the C2C concept were identified as shown in Table 1.

Table 1: Summary of the Challenges in Application of C2C Concept

Item	The challenges of C2C concept	Authors
1.	Attitude and culture in different region of the world.	[5]
2.	An excuses from industries to implement this concept.	[5]
3.	The level of education and exposure to this concept.	[6]
4.	Lack of technical expertise in operating and applying this concept.	[7]
5.	Differences in the level of technology and the unwillingness of local communities to accept new technologies and facilities.	[6]
6.	The increasing quantity and waste types.	[8]
7.	A lack of public compliance.	[7]
8.	Acts and regulations related to waste management been implemented well and suitable.	[3]
9.	The lack of coordination and overlapping of responsibilities.	[7]
10.	The financial constraints is severely limit the effectiveness of waste management.	[7]
11.	Food wastage and its management	[9]
12.	High land prices, strict environmental regulations, health and safety issues, improper management of waste disposal sites and limited landfill spaces.	[6]
13.	Reduce the waste in every sectors and landfill areas.	[5]

Based on Table 1, the list of 13 challenges in application of 'Cradle-to-Cradle' was identified. It will be used for further analysis

2. Methodology

This section explains the methodology of this study. The methodology should justify the design choices by demonstrating that the methods and techniques chosen are best suited to the research goals and objectives and will produce valid and reliable results. In this chapter, literally discussed the approach and techniques used to perform this research. For this research, the quantitative method has been chosen to establish the challenges in the application of 'Cradle-to-Cradle' concept in waste management.

2.1 Methodology framework

Initially, data for this study was gathered through a literature review, which helped to give important information about the facts and challenges of 'Cradle-to-Cradle' concept in waste management. In addition, questionnaire were used in this study to obtain information from industry players and related individuals on this field. Then, the questionnaire will be analyse in order to achieve the goals of this research. In the final discussion of this study, the overall statement will be concluded and some recommendations that are suitable for usage in the future will be provided. The methodology procedures are simplified as the following flow chart, as shown in Figure 1.

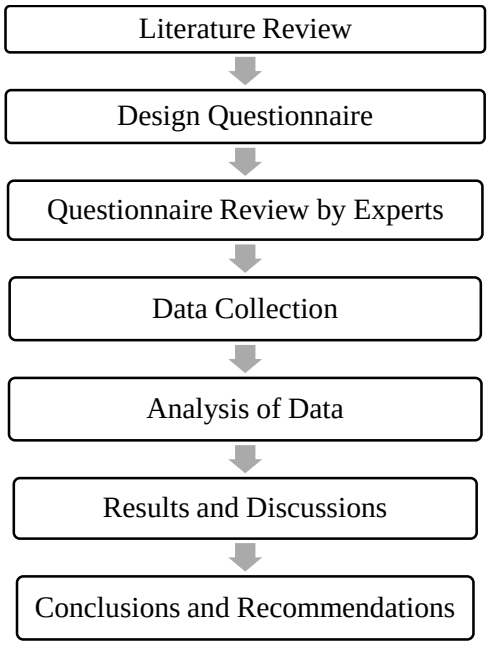

Figure 1: Flowchart of design framework

2.2 Methods

In this study, a set of questions about the challenges in the implementation of the 'Cradle-to-Cradle' concept in waste management will be distributed to relevant agencies such as university lecturers from UNITEN, Indah Water Konsortium Sdn Bhd (IWK) and the Public Works Department (JKR), in order to determine the challenges of applying this concept in waste management. The number of sample sizes was calculated using the Taro Yamane formula for finite and small populations. Next, in order to determine the reliability of the multi-question Likert scale, Cronbach's Alpha method was used. Hence, reliability analysis was conducted by using SPSS software to acquire the consistency of the parameters. Then, Principal Component Analysis (PCA) was conducted to reduce the dimensionality of data sets, increasing interpretability while at the same time minimising information loss. PCA was also conducted using SPSS software.

2.3 Equations

Sample size was obtained by using Taro Yamane formula which is very suitable for small population and finite population [10] as below:

$$n = \frac{N}{1+Ne^2} \qquad Eq.1$$

Where,

n = Required sample size

N = The population size

e = Margin error (0.10, 0.05 or 0.01)

There are 150 lecturers in College of Engineeing from UNITEN, 3288 employee from IWK and 214 employee from JKR Putrajaya. By using all population values, the minimum sample size were obtained. In this case, the margine of error that used was 90% which is 0.10 in decimal.

Value obtained,

N = 3652 (1.1)

e = 0.10 (1.2)

Subtituiting the values of (1.1) and (1.2) into formula $Eq.1$ to calculate the number of sample sizes. The number of sample size obtained are shown below:

$$n = \frac{N}{1 + Ne^2}$$

$$n = \frac{3652}{1 + 3652(0.10)^2}$$

$$n = 97.33 \approx 97$$

By using this method, sample size that obtained is 97. Hence, the minimum number of sample size that needed for this research is 97 respondents.

3. Results and Discussions

Two analyses were included in this study, which were the Cronbach's Alpha method to determine the reliability and acceptance of the multi-question Likert scale, and the PCA test was conducted to reduce the dimensionality of the data, increase interpretability, and at the same time minimised information loss.

3.1 Cronbach's Alpha method

There were 13 challenges was identified after collections of the data from questionnaire. The Cronbach's Alpha method was used to analyse all 13 challenges by using SPSS software to check the reliability and acceptance of the data. The of Cronbach's Alpha should be greater than 0.7 to consider it as acceptable and reliable result but the result obtained less than 0.7, some data should be removed until the result exceed acceptable value. Table 2 shows the value of Cronbach's Alpha.

The result from Table 2 shows that the value of Cronbach's Alpha for 13 challenges of application of 'Cradle-to-Cradle' concept is 0.852. Based on result of analysis, the challenges of application of the concept are reliable and acceptable since the value of Cronbach's Alpha is more than 0.7.

Table 2: Cronbach's Alpha Value

No.	The challenges of C2C concept	Mean	Standard Deviation	Cronbach's Alpha
1.	Reduce the waste in every sectors and landfill areas.	4.529	0.5396	0.852
2.	Attitude and culture of Malaysians.	4.539	0.7793	
3.	The level of education and exposure to this concept.	3.892	0.7949	
4.	Lack of technical expertise in operating and applying this concept.	4.490	0.5584	
5.	Differences in the level of technology and the unwillingness of local communities to accept new technologies and facilities.	4.529	0.6086	
6.	The increasing quantity and waste types.	4.412	0.5862	
7.	A lack of public compliance.	4.343	0.5539	
8.	An excuses from industries to implement this concept.	3.971	0.7373	
9.	Acts and regulations related to waste management been implemented well and suitable.	3.696	0.8058	
10.	The lack of coordination and overlapping of responsibilities among various government agencies and different levels of local government.	4.324	0.5657	
11.	The financial constraints	4.225	0.6434	
12.	Food wastage and its management.	4.284	0.5518	
13.	High land prices, strict environmental regulations, health and safety issues, improper management of waste disposal sites and limited landfill spaces.	4.304	0.6100	

3.2 Principal Component Analysis (PCA)

At the same time, PCA is used in this study to reduce the dimensionality of the data sets while simultaneously minimising information loss [11]. By using PCA, the eigenvalue and percentage of cumulative eigenvalue were obtained based on 13 challenges as a component in the data set, as in Table 3. Then, the scree plot of 13 challenges will be presented as shown in Figure 2. Next, Table 4 shows the coefficient score for the coefficient matrix of the identified challenges in the application of the 'Cradle-to-Cradle' concept in waste management. Finally, Table 5 contains a summary of the Principal Component Analysis (PCA) results.

Table 3: Total Variance of Initial Eigenvalues

Component	Initial eigenvalues		
	Total	% of Variance	Cummulative %
1	5.109	39.300	39.300
2	1.817	13.978	53.278
3	1.090	8.386	61.664
4	0.956	7.350	69.014
5	0.707	5.438	74.452
6	0.633	4.868	79.319
7	0.552	4.248	83.567
8	0.490	3.771	87.338
9	0.424	3.262	90.600
10	0.408	3.139	93.739
11	0.331	2.547	96.286
12	0.285	2.190	98.476
13	0.198	1.524	100.00

Based on table 3, the principal component of the correlation matrix shows three eigenvalues, which is more than one. The result above shows the highest eigenvalues were 5.109, with a percentage of variance of 39.3%. Then, followed by a second component with more than one eigenvalue, the total was 1.817 with a 13.978% eigenvalue. However, the eigenvalues for principal component three were 1.090 with 8.836% of variance. Then, the total cumulative percentage of initial eigenvalues for three components that had more than one was 61.66%.

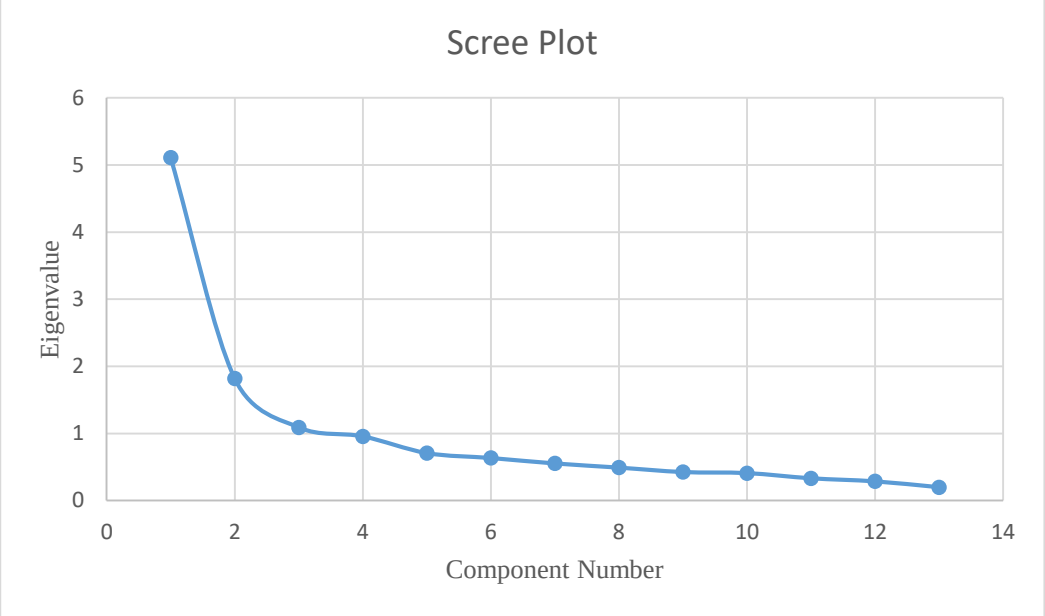

Figure 2: The scree plot for 13 component of challenges in application of C2C concept in waste management.

Based on Figure 2, there were three component shows the eigenvalues more than one which is component 1, 2 and 3 by 13 component of the challenges in application of 'Cradle-to-Cradle' concept in waste management.

Table 4: Coefficient Score for Coefficient Matrix

No.	The challenges	Component		
		1	2	3
1.	Reduce the waste in every sectors and landfill areas.	0.699	-0.034	0.199
2.	Attitude and culture of Malaysians.	0.502	-0.413	0.559
3.	The level of education and exposure to this concept.	0.397	0.580	0.480
4.	Lack of technical expertise in operating and applying this concept.	0.680	-0.399	0.252
5.	Differences in the level of technology and the unwillingness of local communities to accept new technologies and facilities.	0.625	-0.459	0.153
6.	The increasing quantity and waste types.	0.685	-0.215	-0.195
7.	A lack of public compliance.	0.693	0.109	-0.288
8.	An excuses from industries to implement this concept.	0.507	0.560	-0.074

No.	The challenges	Component		
		1	2	3
9.	Acts and regulations related to waste management been implemented well and suitable.	0.397	0.713	0.280
10.	The lack of coordination and overlapping of responsibilities.	0.755	-0.074	-0.101
11.	The financial constraints is severely limit the effectiveness of waste management.	0.672	0.159	-0.248
12.	Food wastage and its management.	0.691	0.127	-0.270
13.	High land prices, strict environmental regulations, health and safety issues, improper management of waste disposal sites and limited landfill spaces.	0.704	-0.106	-0.267

Table 4 above shows the three coefficient scores coefficient matrix that produced by SPSS software. The cricital challenge is the maximum value than closed to one or more than one. Thus, others challenges give small effect when compared to critical challenges.

In the analysis of coefficient matrix for principal component one, the most critical challenges are high land prices, strict environmental regulations, health and safety issues, improper management of waste disposal sites and limited landfill spaces. Besides that, the principal component two, the most critical challenges are acts and regulations related to waste management been implemented well and suitable. The principal component three, the most critical challenges are attitude and culture of Malaysians. Therefore, the result can be tabulate and summarized as shown in Table 5 below.

Table 5: Summary of Principal Component Analysis (PCA) Results

No.	The challenges	Component		
		1	2	3
1.	Reduce the waste in every sectors and landfill areas.	0.699	-	-
2.	Attitude and culture of Malaysians.	-	-	0.559
3.	The level of education and exposure to this concept.	-	0.580	0.480
4.	Lack of technical expertise in operating and applying this concept.	-	-	0.252
5.	Differences in the level of technology and the unwillingness of local communities to accept new technologies and facilities.	-	-	-
6.	The increasing quantity and waste types.	-	-	-
7.	A lack of public compliance.	-	-	-
8.	An excuses from industries to implement this concept.	-	0.560	-

9.	Acts and regulations related to waste management been implemented well and suitable.	-	0.713	-
10.	The lack of coordination and overlapping of responsibilities.	0.755	-	-
11.	The financial constraints is severely limit the effectiveness of waste management.	-	-	-
12.	Food wastage and its management.	-	-	-
13.	High land prices, strict environmental regulations, health and safety issues, improper management of waste disposal sites and limited landfill spaces.	0.704	-	-

Table 5 above shows the Principal Component Analysis (PCA) by using SPSS software. From the PCA result above, the critical challenges in the application of 'Cradle-to-Cradle' concept in waste management are (1) the attitude and culture of Malaysians, (2) the level of education and exposure to this concept, (3) lack of technical expertise in operating and applying this concept, (4) acts and regulations related to waste management that have been implemented well and suitably, and (5) excuses from industries to implement this concept.

3.3 Proposed solutions

From the Principal Component Analysis, the result shows the total of five critical challenges in the application of 'Cradle-to-Cradle' concept in waste management, which are the attitude and culture of Malaysians, the level of education and exposure to this concept, lack of technical expertise in operating and applying this concept, acts and regulations related to waste management that have been implemented well, and excuses from industries to implement this concept. Thus, the result of critical challenges can be used for further analysis, and the proposed solution can be made related to the challenges in the application of this concept to improve the implementation of the 'Cradle-to-Cradle' concept in waste management in Malaysia.

Attitude and culture are two different things that human beings practise and learn from children. Attitudes can shift or become stronger. Therefore, in order to ensure the success of this concept, all citizens should change their attitude and try to practise a new lifestyle. In Malaysia, culture is a symbol of race. Malaysians are very compliant. Therefore, cultural influences can be one of the critical challenges in the application of this concept, and they are not accustomed to the application of this concept. In order to ensure this concept is well applied, all Malaysians must change their attitude related to managing their waste at home and, indirectly, this can help in minimising the production of waste. The awareness of consumers about the environmental impact resulting from their respective demands has motivated voluntary efforts to reduce the ecological footprint.

The level of education about this concept can be the main reason the failure of this concept in Malaysia. It is because the knowledge about managing the waste is very limited. Then, lack of exposure to this concept from appropriate party causing this concept to not be properly applied. Malaysians still do not understand the concept of 'Cradle-to-Cradle' and many still practice the concept of Cradle-Grave. So that, government or private which related to waste management should be responsible to give some exposure and education about this concept to increase their knowledge and indirectly can improve and many Malaysians can apply it well.

Due to a lack of experience in this area, less effort is put forth into the management of waste in a sustainable manner. Furthermore, findings showed that trained employees do not prefer to stay long enough in an organisation to assist in sustainable management. As mentioned before, lack of technical

expertise can be one of the reasons this concept cannot go well. It will have some cost constraints because training one employee in professional training is a cost. However, education from schools and universities can help to produce expertise in applying this concept.

The goals of building acts and regulations were to reduce the potential hazards to people and the environment. Under the Environmental Quality Act (EQA) of 1974, the government has enacted a number of legal provisions pertaining to planned waste generation, storage, transportation, and disposal. The EQA was implemented in 1975 and amended in 1976, 1985, and 1996 in accordance with international standards. However, there were some people who are not responsible for dumping garbage evenly, for example in forests, bush areas, rivers, and areas with small populations. The authorities need to conduct more frequent surveys and monitoring, even if the area has warning signs. Such a thing can frustrate this concept because a lot of reusable waste is dumped everywhere and causes pollution to the environment. Other than that, a large amount of compound should be imposed on companies and individuals who cannot follow the regulations and rules while giving tax relief to those who comply with the laws and practise this concept.

In Malaysia, very little research on sustainable waste management has been done to date. Due to the drastic growth in manufacturing activities and hazardous waste, it is critical to investigate potential challenges to sustainable waste management in Malaysia. The consequence of waste mishandling, even in small amounts, is sometimes intolerable for some small countries with delicate natural environments. DOE Malaysia is also aggressively promoting a shift from 'Cradle-to-Grave' approach, in which wastes are treated as unwanted by-products, to ‘Cradle-to-Cradle’ approach, in which hazardous wastes are regarded as alternative resources with potential for energy recovery. It demonstrates that the application of this concept in Malaysia is not the primary option for waste management. The company that produced the largest amount of waste cannot give an excuse for not supporting this concept. It is because, with the participation of the industry, it can help in reducing environmental pollution and reducing waste. However, improper management of waste disposal sites and limited land filling shows that Malaysians need to practise the 'Cradle-to-Cradle’ concept to avoid dumping garbage in disposal areas due to the limitation of landfill space.

4. Conclusions

As a conclusion, the first objective of this study, which is to identify the challenges in the application of ‘Cradle-to-Cradle’ concept in waste management, was successfully achieved by using SPSS software in two different methods of analysis, namely, the Cronbach’s Alpha method and the PCA test. Therefore, five critical challenges were determined, which are: (1) the attitude and culture of Malaysians, (2) the level of education and exposure to this concept, (3) lack of technical expertise in operating and applying this concept, (4) acts and regulations related to waste management being implemented well and suitable, and (5) excuses from industries to implement this concept.

Then, the second objective, which is to propose solutions for the challenges in the application of ‘Cradle-to-Cradle’ concept in waste management, was achieved. The solution was proposed based on the five critical challenges identified through PCA analysis. First, the attitude and culture of Malaysians. Attitude can be changed by practising new habits on a regular basis, while good habits, especially when applied to this concept, can create a new culture. Next, consider the level of education and exposure to this concept. To increase the level of education in society towards this concept, the government can provide specific subjects regarding this concept from primary school. Then, government or private entities that are proficient in the environment and apply this concept can do some classes, training, talks, or campaigns to educate people about the application of ‘Cradle-to-Cradle’ concept since the knowledge and skilled people are very limited. Besides that, a lack of technical expertise in operating and applying this concept. To give information and education about this concept, agencies such as CIDB, JKR, and DOE can give professional training to people from educational backgrounds, and so on. In Malaysia, there are many acts and regulations related to the environment. But the implementation of acts of law is very limited. The government should impose a penalty on individuals or companies that cannot follow the law and cannot follow this concept. Finally, an industry justification for implementing this concept.

Cooperation from companies in implementing this concept is very important, especially for companies that produce a lot of waste every day. This can help reduce environmental pollution.

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