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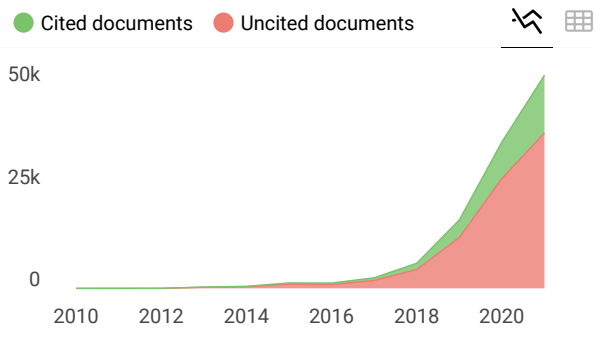
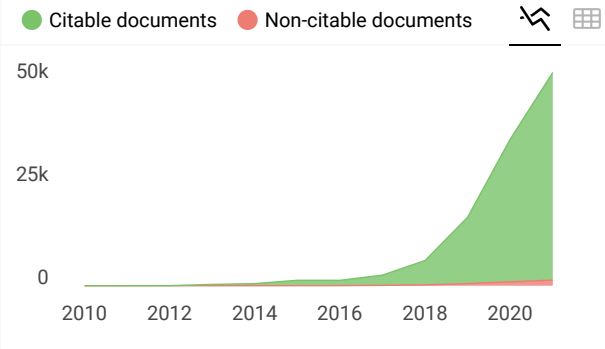
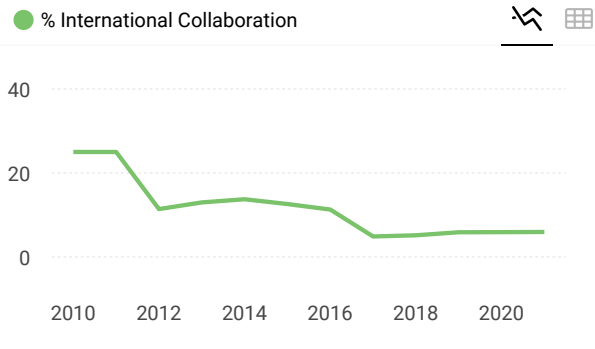
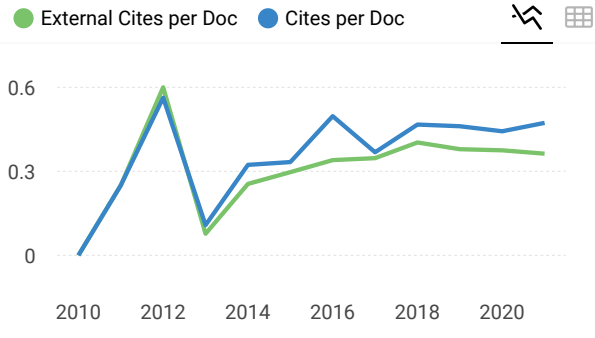
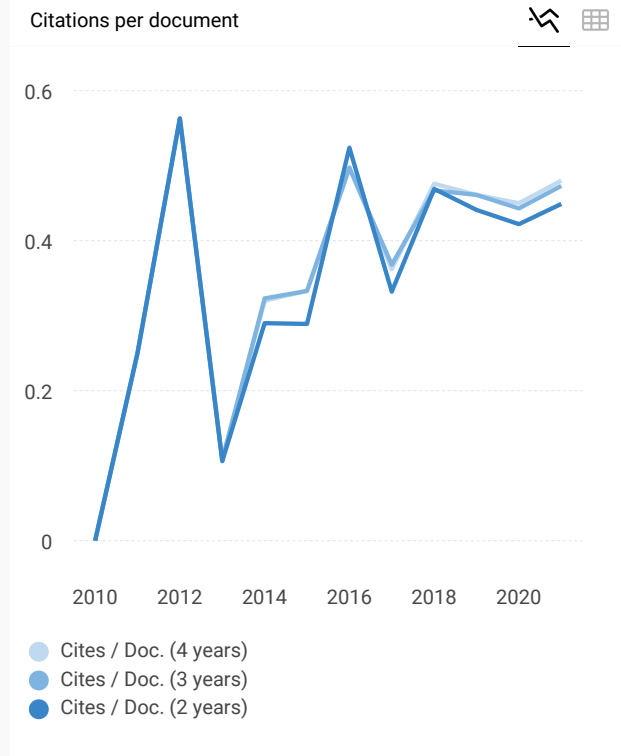
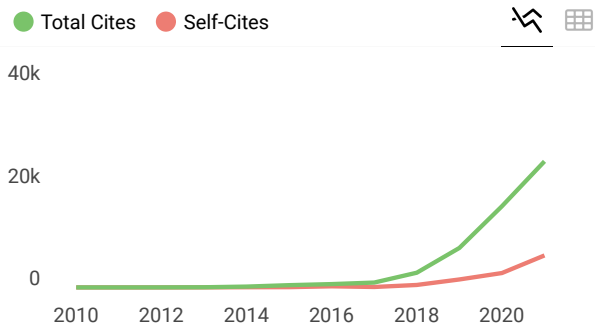
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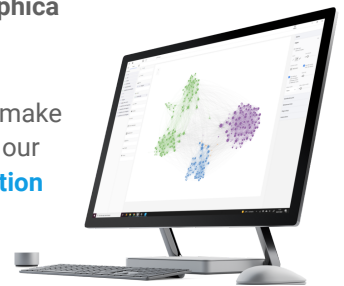
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## Waste management planning toward zero waste in Hotel XYZ Bandung with circular economy principles (case study: room service facility's solid waste)

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# Waste management planning toward zero waste in Hotel XYZ Bandung with circular economy principles (case study: room service facility's solid waste)

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**Abstract.** Hotel XYZ is a commercial area in the city of Bandung which still applies the traditional linear economic cycle. The 61.61% of ±9000 m<sup>2</sup> building area is used for room service facilities. The hotel has not paid attention to its waste management so all the waste generated from this hotel end up at the landfill area. This study aims at improving the waste management in Hotel XYZ to meet the principle of circular economy. Using SNI 19-3964-1994 approach to measure the generation of waste composition, the amount of waste generated from room service facilities is 0.03 kg/m<sup>2</sup>/day or 0.41 liter/m<sup>2</sup>/day. The zero waste index (ZWI) calculation was used for the evaluation of waste management in the hotel. The waste generated at Hotel XYZ has the potential to achieve substitute material savings by 63.16 kg, substitution of energy by 775.79 MegaJoule (MJ), greenhouse gas (GHG) reduction by 49.36 kg/CO<sub>2</sub>e, -164.06 L/ kg of water saving. The most waste generated by hotel room service facilities is recyclable waste consisting of single-use packaging from hotel equipments. Waste reduction plan for the room service facilities is carried out by replacing single-use packaging with refillable packaging so the hotel is able to save their shopping expenditure costs up to Rp. 844,691.00 per day.

## 1. Introduction

Garbage is all types of solid waste originating from human and animal activities, and is disposed of because it is not useful or is no longer wanted [1]. This waste problem can be overcome by managing waste in accordance with the existing field conditions and using reference to regulations or standards set by the government. Waste reduction efforts can be described as waste generation limitation, waste recycling or waste reusing, and it is known as 3R (Reduce, Reuse, Recycle). The 3R principle is related to the concept of Zero Waste (ZW) which can be interpreted as an effort to design a cycle of resource that includes processes to maximize recycling, minimize waste, and streamline consumption or at least turning it so it can be recycled so that the impact of disposal can be reduced by nature [2].

Hotel XYZ is a part of the commercial area in Bandung which has complete facilities and services for the convenience of its visitors. As much as 61.61% of the area of this hotel is a room service area, so it can be said that the facility is the source that generates the most waste. The products used by these visitors generally use inorganic-based packaging, especially plastic and are used for single-use, which after consumption, it will end at the landfill site. This activity shows that the economic cycle applied by Hotel XYZ is a traditional linear system of take-make-consume-dispose activities, even though the remaining products still have selling value and still have the potential to be reused or recycled.

The plan to change the hotel's linear system into a circular economy aims to extend the life of waste into something useful to be reused as an alternative raw material or recycled into new products[3]. If the



implementation towards zero waste with the circular economy principle is implemented in this hotel, it is hoped that Hotel XYZ's operations can be more efficient in terms of expenditure costs and the generation of waste can be minimized. An index is an important tool to measure environmental performances [4-6]. Zero waste index (ZWI) is a tool to measure the potentiality of virgin materials to be offset by zero waste management systems[3]. Guided by the advantages of implementing ZWI [3], the improvement of the waste management system can be measured through an evaluation so that it can continue to be improved. However, the use and application of ZWI to assess the circular economy implementation has not been done anywhere in Indonesia.

This research will focus on efforts to reduce waste by referring to one of the main principles of the circular economy, which is "saving the products and materials used"[7] using the 3R (Reduce, Reuse, Recycle)[8] approach where some waste materials will be reused as raw materials or recycled, becoming new products to save production costs, or replace single-use materials with materials that are reusable so that the cost savings of resource spending is maximized and waste generation can be reduced to almost zero (zero waste).

## 2. Method

This research was conducted in March 2020, where the sampling measurements were carried out for 8 days, referring to SNI-19-3964-1994[1] for non-residential waste and load count analysis [13]. The waste measured is the waste that goes to the hotel's dry garbage waste temporary disposal site, then the waste is sorted based on its composition to calculate the percentage composition of the generated waste. The calculation of hotel equipment shopping expenditure uses the following formula.

$$SE = \frac{\text{Total weight of each composition per day (g)}}{\text{Weight of each item (g)}} \times \text{price (IDR)} \quad (1)$$

Estimating expenditure on hotel room equipment spending is done by dividing the total weight of the waste composition produced by the weight of 1 composition item then multiplied by the unit price of the composition item. The results of the calculations are then set aside with expenditures from the planning so that the cost savings from the implementation of planning are obtained, as shown in Table 1.

**Table 1.** Price List of Hotel Room Equipments [9] [10]

Item(s)	Weight per item (g)	Price
Mineral Water (Plastic Bottles)	17	Rp2,400
Liquid Amenities	12	Rp2,302
Bar Soap	25	Rp1,417
Toothbrush	14	Rp1,450

After calculating the expenditure on hotel equipment, the payback period is calculated to determine the investment return period from changing the use of single-use packaging products to refill packaging. The payback period (PP)[11] equation that can be used is as follows:

$$PP = \frac{\text{investment}}{\text{cash flow}} \times 1 \text{ year} \quad (2)$$

The zero waste index (ZWI) is a cutting-edge tool to measure virgin material substitution by waste management systems. By introducing the ZWI globally, we could measure the virgin material offset

potentiality and the potential depletion of natural resources [12]. In this study, ZWI was performed to evaluate the waste management in the hotel

$$ZWI = \frac{\sum_1^n WMSi * SFi}{\sum_1^n GWS} \quad (3)$$

WMSi is amount of waste managed by system i (i.e. i=1, 2, 3...) and n is amount of waste avoided, recycled, treated, etc. SFi is a substitution factor for different waste management systems based on their virgin material replacement efficiency as presented on Table 2, while GWS is total amount of waste generated (tonnes/kg of all waste streams).

**Table 2.** SFi of the resources for the Zero Waste Index [12]

Waste management systems	Waste category	Virgin material substitution efficiency (tonnes)	Energy substitutions efficiency (GJLHV/tonne)	GHG emissions reduction (Tonne/CO2e)	Water saving (kL/tonne)
Recycling	Paper	0.84-1.00	6.33-10.76	0.60-3.20	2.91
	Glass	0.90-1.00	6.07-6.85	0.18-0.62	2.3
	Metal	0.79-0.96	36.09-191.42	1.40-17.8	5.97-81.77
	Plastic	0.9-0.97	38.81-64.08	0.95-1.88	-11.37
	Mixed	0.25-0.45	5.00-15.0	1.15	2.0-10
Composting	Organic	0.6-0.65	0.18-0.47	0.25-0.75	0.44
Landfill	Mixed MW	0	0.00-0.84	(-)-0.42-1.2	0

### 3. Results and discussion

#### 3.1. Hotel room service's waste generation and composition

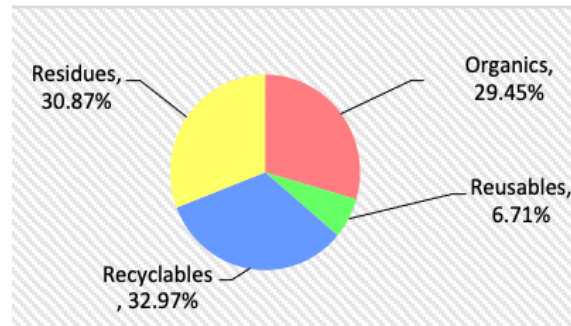
Table 3. shows that the average waste generation generated from the Hotel XYZ room service facility is 0.03 kg/m<sup>2</sup>/day or 0.41 liter/m<sup>2</sup>/day.

**Table 3.** Waste Generation of Hotel Room Service Facility

No.	Days	W (kg)	V (m <sup>3</sup> )	qw (kg/m <sup>2</sup> /day)	qv (liter/m <sup>2</sup> /day)
1	Friday	121.63	2.51	0.03	0.41
2	Saturday	233.65	2.36		
3	Sunday	281.94	3.27		
4	Monday	179.79	3.30		
5	Tuesday	139.31	2.61		
6	Wednesday	91.74	1.64		
7	Thursday	99.52	1.19		
8	Friday	109.33	1.93		
Total		1256.9	18.8		
		0	1		
Average Weight and Volume		157.11	2.35		
Density (kg/m <sup>3</sup> )		66.808			

Notes: W= Weight, V= Volume, qw= weight debit, qv= volume debit

The amount of waste generated is based on existing conditions during the Covid-19 pandemic and this is related to the Room Occupancy Rate (ROR) based on data from the Central Statistics Agency for West Java Province (2020), where the ROR for 4-star hotels in March is 34.15%.[13] The composition resulting from hotel commercial activities is divided into 4 types, namely organic, reusable, recyclable, and residues.



**Figure 1.** Weight Percentage of Room Service Facility Waste Compositions

Figure 1 shows that the largest waste generated from the room service facilities is recyclable waste. This is due to the use of single-use items such as the use of mineral water packaged in plastic bottles, liquid amenities, cans, paper, and others.

These materials can be recycled to produce new goods without having to take new resources so that the principles of the circular economy can be implemented. This waste management planning towards zero waste uses a 3R approach. Waste reduction plan is carried out by replacing mineral water and liquid amenities that use single-use bottles into refillable packages so that in the future there will be no more compositions of amenities bottles and plastic bottles in the waste generation from room service. Reuse can be done by reusing items that have been previously used, such as paper back pages or reusing cardboard to package items. Recycling waste such as paper, cans, glass, plastic, and so on can be done by selling to a recycler to be used as raw material for production or converted into other forms so that it can provide different functions than before. This is in line with the principles of circular economy and supports the national government's plan to reduce the waste being distributed to landfill.

### 3.2. Hotel Room Equipment Shopping Expenditure

The results of the calculation of expenditure (SE) for hotel equipment that will be replaced with refill packaging or replacement of materials such as mineral water, liquid amenities, bar soap, and toothbrush at room service is shown in Table 4.

Composition(s)	Weight (%)	Weight/ day (kg)	Weight / composition (kg)
Plastic Bottles	7.33%		11.51
Liquid Amenities Packaging	5.26%	157.11	8.27
Bar soap	4.09%		6.43
Toothbrush	1.25%		1.97

The alternative that can be done to reduce the amount of liquid amenities packaging waste that enters the dry garbage temporary disposal site is to replace the liquid amenities packaging such as 60 ml

shampoo, 35 ml bath gel, 35 ml conditioner and 35 ml body lotion on a single bottle to a 350 ml volume soap dispenser and a pump bottle for liquid soap which is refillable. The initial investment cost incurred by the hotel to replace the use of disposable liquid amenities with refillable packaging is Rp. 33,681,200.00. The payback period (PP) for the required liquid amenities is 24 days. This is obtained from the division between the nominal spending on refilling soap dispensers and the cost savings for shopping from liquid amenities and bar soap, which is Rp. 1,396,871.00. It is assumed that the zero waste implementation plan takes 1 year, because the PP is less than 1 year, so the investment for purchasing liquid amenities refill packaging is considerably feasible. By doing this, the benefits will be accrued by many stakeholders. The government will have less expenditure on city waste management, and the hotel will have economic benefits from changing the way it manages the solid waste, as shown in Table 5. Of the utmost important, it will provide massive benefit to the environment through the saving of valuable resources.

**Table 5.** Comparison of Hotel Equipment Shopping Expenditure

Items	Existing Conditions	Zero Waste Implementation	Saved Cost
	Shopping cost/day	Shopping cost/day	
Mineral Water (Plastic Bottle)	Rp. 840,000.00	Rp. 600,000.00	Rp. 240,000.00
Liquid Amenities	Rp. 1,585,881.00	Rp. 553,235.00	Rp. 1,032,645.00
Bar Soap	Rp. 364,226.00	Rp. -	Rp. 364,226.00
Toothbrush	Rp. 472,700.00	Rp. 1,264,880.00	-Rp. 792,180.00
		Total	Rp. 844,691.00

Reducing waste by replacing single-use packaged items with refillable or recyclable ones can minimize hotel spending. There is no daily shopping expenditure for bar soap because shower gel amenities have the same function as bar soap, so that in the next application there is no need to spend on bar soap. The occurrence of negative points on toothbrushes is because the replacement of plastic toothbrushes and those made of bamboo has different prices. However, this is done because the circular economy does not only look at the benefits obtained but also from the environmental aspect.

### 3.3. Zero Waste Index (ZWI)

Table 6 below shows the potential substitution of resources of the recycling programs, in the form of Zero Waste Index (ZWI).

**Table 6.** Potential Substitution of Resources in The Zero Waste Index

Waste management systems	Waste category	Total Waste Managed (kg)	Potential	Total energy substituted (MJ)	Total GHG emissions reduction (Kg/CO <sub>2e</sub> )	Total Water saving (L)	ZWI
			total virgin material substituted (kg)				
Recycling	Paper	19.85	16.67	125.64	11.91	57.76	0.67
	Glass	3.39	3.05	20.56	0.61	7.79	
	Metal	0.36	0.29	13.16	0.51	2.18	
	Plastic	14.43	12.99	560.01	13.71	-164.06	
	Mixed	9.62	2.40	48.09	11.06	19.24	
Composting	Organic	46.27	27.76	8.33	11.57	20.36	

Landfill	Mixed MW	0.00	0.00	0.00	0.00	0.00
	Total	93.92	63.16	775.79	49.36	-56.74

The ZWI Hotel XYZ calculation took a scenario where the waste reducing plan is implemented so that in the future there will be no more compositions of amenities bottles and plastic bottles in the waste generation from room service. The ZWI result is 0.67. This means that 67% of solid waste generation can be recovered by the waste management system. The waste management system at Hotel XYZ has the potential to substitute for energy needs by 775.79 MegaJoule (MJ), greenhouse gas (GHG) emissions by 49.36 kg/CO<sub>2e</sub>, and cannot save water because its 164.06 L/ kg of water is used for plastic materials.

#### 4. Conclusion

This paper presents how the implementation of 3R on a commercial area such as hotel as an initial reference for “grounding” the zero waste approach. By doing the 3R implementation such as replacing single-use packaging into refillable packaging, we can reduce the 32,97% recyclable waste in the future also save spending on hotel supplies by Rp. 844,691.00 per day. Also, 0,67 ZWI or around 67% of room service facilities waste can be substituted for material savings by 63,16 kg, substituting energy needs by 775.79 Mega Joule (MJ), greenhouse gas emissions (GHG) by 49.36 kg /CO<sub>2e</sub>, and has not been able to save water because 164,06 L/kg of water is used for processing plastic materials. For future reference, similar study can be extended to also include the detailed solid waste management for the organic waste.

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