

## Technical and Financial Assessments of Depo 3R Palasari, Denpasar

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### ABSTRACT

Municipal solid waste (SW) has become a serious problem in Denpasar City. Due to the space limitation for landfill, it is necessary to intensify the SW reduction activity. Operation of Material Recovery Facility (MRF) from the SW is one of the solutions to overcome the problem. Depo 3R Palasari is an MRF, which is located in Sanur Kauh Sub-district, South Denpasar District. The SW management in this Depo has not worked satisfactorily. This Depo could only reduce 1.71% of the treated SW, and 98.29% of the SW should be disposed to the landfill. This Depo also faced financial problem, in which the revenue income could not cover the operational costs. Therefore, this study aimed to assess the technical and financial performances of the Depo. The SW amount, which was received by the Depo, was measured using load count analysis method for 8 consecutive days. This research also determined the SW composition, density, and recovery factor. Mass balance analysis was performed for estimating revenue and facility needs. Financial assessment was done using Net Present Value (NPV) and Benefit Cost Ratio (BCR) methods. The results showed the Depo received 3,478.82 kg of SW/day. With average SW density of 160.98 kg/m<sup>3</sup>, the received SW amount was 21.61 m<sup>3</sup>. The SW was composed of 80.48% biodegradable component, 9.06% plastic, 2.08% paper, cardboard and carton, and the remaining components were tetra pack, glass, metal, rubber, and others. Estimated SW amount which will be received by the Depo in 2027 was 4,054.15 tons/day. The SW reduction potential was 25.54%. This reduction level can be achieved if the Depo is expanded from 546.88 to 990.89 m<sup>2</sup> in 2027. The current NPV value was negative (IDR-102,062,182.52). This NPV value could be increased by improving the current 3R capacity from 1.71% to 16.90%, and increasing the number of labors from 2 to 10 staff. The Depo is financially feasible (NPV = IDR. 26,193,368.50, BCR = 1.01) in 2027 if provided with financial support from the local government.

**KEYWORDS:** optimization, 3R facility, solid waste, South Denpasar

### INTRODUCTION

Municipal solid waste (SW) has become a serious problem in big cities with high population density [1] in Indonesia, including in Denpasar City, Bali. Pollution due to the unmanaged SW can cause adverse effects to the environment. These impacts not only pollute the environment, but also can directly affect the economy of Bali, which is dependent on tourism [2].

Based on Act No. 18 Year 2008 concerning Solid Waste Management, municipal SW management activities include reduction and handling activities [3]. The reduction activities not only aimed to reduce the amount of SW, but also to reduce the toxicity [4]. The reduction activities include limiting the SW generation, recycling and reuse. These activities are known as 3R (reduce, reuse, recycle) principles [5]. These 3R principles can reduce the amount of MSW, which should be disposed to the landfill [6]. This can solve land limitation for landfill in big cities in Indonesia, and minimize public health and environmental risks. One of the manifestations of MSW reduction with the 3R principles is the provision of a solid waste treatment facility, or known as material recovery facility (MRF).

Depo 3R Palasari is an MRF in South Denpasar District [7]. It was built in 2005 and managed by a community organization (KSM). This Depo has 546.88 m<sup>2</sup> area, which is used for sorting, composting, storage, placement for residual matter containers, collection vehicles parking area and office [8]. The Depo currently served 952 families or 3,771 people. The facilities include 5 collection vehicles, a shredder, and a compost sieve machine. However, at present both composting facilities are not working. The SW management in this Depo has not worked satisfactorily. This Depo could only reduce 1.71% of the SW, including 0.34% of the biodegradable waste. The 98.29% of the SW should be disposed to the landfill. The SW collection fee is IDR.20.000 for each house holder. The payment participation rate is 78.15%. The Depo serves 23.32% of the total population in Sanur Kauh Sub-district. The rest of the SW (76.68%) of the SW is managed by private sector. Trucks for transporting the SW to landfill are provided by Head of the Sub-district.

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Depo 3R Palasari conducts composting activities, but in limited quantity. Revenue from sale of the products and collection fee from the community could not cover the operational costs [9]. Therefore, this study aimed to assess the technical and financial aspects of Depo 3R Palasari.

## MATERIALS AND METHODS

The amount of SW, which was processed in Depo 3R Palasari, was determined by load count analysis method [4] for 8 consecutive days. The SW composition and recycling potential were determined based on the weight percentage of each SW component. The measurement was done for 3 days by sorting the SW components of at least 100 kg [10]. Three SW samples were collected randomly from 3 collection vehicles. This research also used mass balance analysis to determine the facility and financial needs. Development of the Depo was designed for 10 years from 2018 to 2027. Population projection to year 2027, which was calculated from 2008 to 2015 data, was used for SW generation projection. Financial assessment was done by using Net Present Value (NPV) and Benefit Cost Ratio (BCR) methods. If NPV value is higher than 0, and BCR value is higher than 1, the Deposit feasible to operate [11].

## RESULTS AND DISCUSSION

### Technical assessment

The SW quantity which was received in Depo 3R Palasari was 3,478.82 kg/day. With an average density of 160.98 kg/m<sup>3</sup>, the SW volume was 21.61 m<sup>3</sup>/day. Biodegradable organic waste, which comprised food waste and yard waste, was the main fraction (80.48%), with a recovery factor of 41.17% for compost raw material. The second highest SW component was plastic waste (9.06%), of which recovery factor was 87.34%. Composition and recovery factor values of the SW are shown at Table 1.

**Table 1. Composition and recovery factors (RF) in Depo 3R Palasari**

No	Components	Percentage (%)	RF (%)	Recovered SW (kg/day)	Residue (kg/day)
1	Biodegradable organic waste	80,48	41,17	1.152,60	1.647,27
2	Plastics	9,06	87,34	275,39	39,92
3	Tetra pack	0,74	-	-	25,66
4	Papers, cardboards, cartons	2,08	90,17	65,34	7,13
5	Rubber	0,19	-	-	6,60
6	Textiles, leathers	0,23	-	-	8,13
7	Glass	1,12	73,16	28,61	10,49
8	Wood	1,68	-	-	58,56
9	Metal	0,62	100	27,10	-
10	Other	3,62	-	-	126,03
	Total	100,0	-	1.549,03	1.929,79
<b>Total solid waste received by the Depo</b>				3.478,82	

The mass balance analysis resulted in 32.00% biodegradable organic waste could be composted (Figure 1). Volume of the composted material would be decreased due to composting process from 35.3% without bioactivator addition to 66.7% with bio activator addition [12]. If 40% of compostable SW is assumed to be composted, the compost product could only achieved 12.80% of the total SW amount. Recovery factor of non-biodegradable waste was 11.40%. This amount could be sold to SW agent as recyclables.

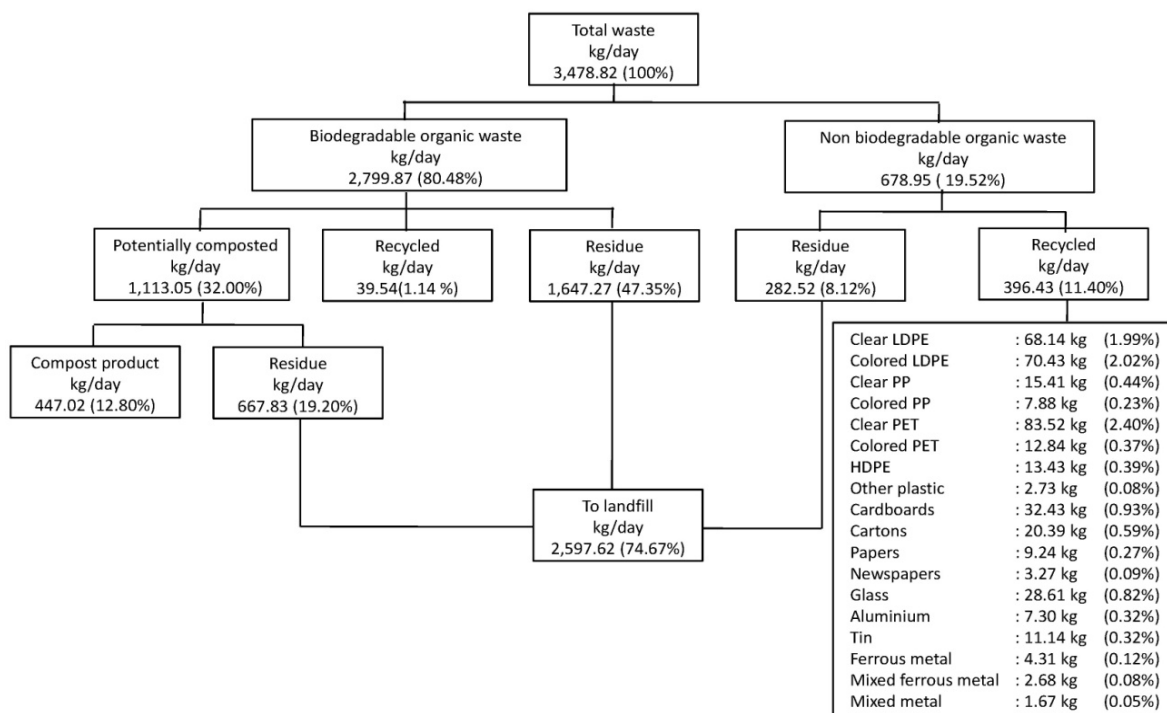


Figure 1. Results of mass balance analysis

Using population projection data until 2027, the estimated SW amount which will be received by the Depo is 4,054.15 kg/day. The Depo would require 990.89 m<sup>2</sup> to treat this amount of SW in 2027, compared to the current 546.88 m<sup>2</sup>. Composting requires the largest area (642.66 m<sup>2</sup>). The current area and the needs for 2027 are shown in Table 2 and Figure 2.

The Depo did not need additional facility in 2027, except residual container. However, in year 2025a new collection vehicle should be provided for replacing an old one. Four new vehicles should be provided in 2026 for replacing the old ones. The number of collection vehicles toward 2027 was determined by optimizing the number collection frequency from 3 to 4 trips per day. An extra container of 8 m<sup>3</sup> capacity was needed for placing residual matter in 2027. The current facility need and in 2027 are shown in Table 3.

Table 2. Estimation of area needs of Depo 3R Palasari in 2027

No	Area	Existing area	Area needs in 2027	Expansion needs
	(m <sup>2</sup> )	(m <sup>2</sup> )	(m <sup>2</sup> )	(m <sup>2</sup> )
1	Unloading and sorting	33.37	38.41	12.01
2	Storage for recyclables	20.82	20.82	-
3	Shredding machine for composting	207.03	642.66	435.63
4	Composting		622.13	
5	Compost maturation area		10.99	
6	Sieving machine for composting		5.22	
7	Packaging and storage of compost product	11.40	11.40	-
8	Container for residual matter	24.08	24.08	-
9	Parking for collection vehicles	57.83	49.16	8.68
10	Leachate pond	0.00	2.15	2.15
11	Office	34.20	34.20	-
12	Worship room	9.00	9.00	-
13	Rest room	2.60	2.60	-
14	Vehicle maneuver	157.95	157.95	-
	<b>Total</b>	546.88	990.89	443.98

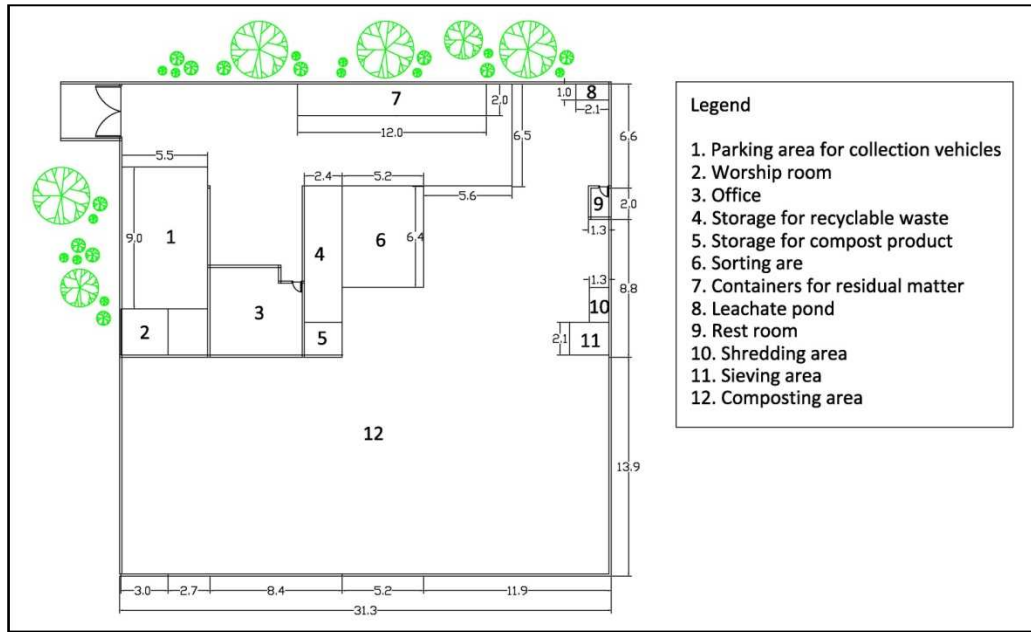


Figure 2. Layout of Depo 3R Palasari in 2027

Table 3. Estimated needs of facilities at Depo 3R Palasari

Year	Amount of solid waste	Collection vehicles	Shredding machine for composting	Sieving machine for composting	Residual matter container
	(kg/day)	(unit)	(unit)	(unit)	(unit)
2018	3.531,36	5	1	1	1
2019	3.583,89	5	1	1	1
2020	3.636,42	5	1	1	1
2021	3.688,96	5	1	1	1
2022	3.741,49	5	1	1	1
2023	3.794,02	5	1	1	2
2024	3.846,55	5	1	1	2
2025	3.899,09	5*	1	1	2
2026	3.951,62	5**	1	1	2
2027	4.004,15	5	1	1	2

Note: \* one new vehicle replaces old one  
 \*\* 4 new vehicles replace old ones

Based on the spatial plan of Denpasar City of 2011-2031, which limits the land use of the surrounding area, it is impossible to expand the depo. Therefore, it is necessary to optimize the 3R activities in the existing area. Optimization can be done by prioritizing the 3R activities of the recyclable waste and limiting the composting biodegradable SW from 32% to 10%. The maximum capacity for composting was 379.73 kg/day. At this recycling capacity, the potential SW reduction that can be achieved by the Depo was 16.90%.

### Financial assessment

Revenue of the depo came from the SW collection fee and the sale of recyclable SW materials. The collection fee was IDR 20.000 per householder. Community participation in paying the collection fee was 78.15% in 2017. This needs efforts to increase community participation in collection fee payment. If assumed that community participation

for collection fee was 10% per year, the estimated revenue would be in 204,578,520.00 in 2018 and IDR 263,040,000.00 in 2027 (Table 4).

Estimated revenue from sales of the of the recyclable materials, such as plastic, paper, glass and metal waste in 2027 was IDR 433.598.450,98. The total income in 2027 was IDR 772,010,292.54 while the operational cost in 2027 was IDR 738,459,566.85. The investment cost was required for providing the collection vehicles rejuvenation, the purchase of compost machines, and the supporting equipment such as packaging tools and scales; whereas the operational cost was for staff salaries, gasoline and vehicle and machinery maintenance.

Data in Table 4 show that the financial cash flow of the Depo in 2018 is deficit. This is due to the high investment cost and the collection fee which is still 78.15%. From 2020 to 2027, the cash flow is positive. With an interest rate of 12%, the estimated NPV value from 2018 to 2027 is IDR -102.062.182,57 and the BCR value is 0.97. Since the NPV and BCR values are negative, the Depo needs financial support from the local government for investment. This will make the NPV and BCR values become IDR 26,193,368.50 and 1,01 respectively.

**Table 4. Financial cash flow in Depo 3R Palasari**

Description	2018	2020	2023	2025	2027
<b>Income</b>					
<b>Collection fee</b>	204,578,520.00	239,040,000.00	249,360,000.00	256,320,000.00	263,040,000.00
<b>Sale of recyclables</b>	154,126,282.42	306,798,299.00	356,233,576.13	393,159,717.43	433,598,450.98
<b>Compost</b>	54,681,402.26	58,723,325.20	65,353,241.59	70,184,002.25	75,371,841.57
<b>Expenditure</b>					
<b>Investment</b>					
<b>Collection vehicles</b>	-	-	-	39,902,971.68	-
<b>Shredded machine</b>	-	-	-	-	-
<b>Sieving machine</b>	13,212,825.00	-	15,791,492.33	-	-
<b>Packaging tool</b>	800.000.00	-	990,838.73	-	-
<b>Scale</b>	2,750,000.00	-	3,406,008.15	-	-
<b>Operational cost</b>					
<b>Salaries</b>	392,532,000.00	554,757,340.80	606,198,324.74	643,115,802.72	716,304,820.64
<b>Gasoline</b>	29,784,442.12	29,791,606.35	29,802,352.69	29,809,516.92	29,816,681.15
<b>Maintenance of collection vehicles</b>	4,663,350.00	5,008,054.06	5,573,467.88	5,985,445.75	6,427,876.08
<b>Machine maintenance</b>	590,691.00	634,353.51	705,972.60	758,156.46	814,197.64
<b>Water and electricity</b>	1,865,340.00	2,003,221.62	2,229,387.15	2,394,178.30	2,571,150.43
<b>Supporting cost for composting</b>	8,953,632.00	9,615,463.79	10,701,058.33	11,492,055.84	12,341,522.07
<b>Total income</b>	413,386,204.68	604,561,624.20	670,946,817.72	719,663,719.68	772,010,292.54
<b>Total expenses</b>	455,152,280.12	601,810,040.14	675,398,902.61	733,458,127.68	768,276,248.00
<b>Cash flow</b>	-41,766,075.44	2,751,584.06	-4.452.084,89	-13,794,408.00	3,734,044.54

## CONCLUSION

Depo 3R Palasari has a potential SW reduction of 25.54%, if expanded from 546.88 m<sup>2</sup> to 990.89 m<sup>2</sup>. Due to the land in avail ability for expansion, the Depo should maximize the SW 3R treatment at its current area. With this option, the Depo can only reduce the SW by 16.90%. From 2018 to 2027 the Depo has an NPV value of IDR -102,062,182.57 (<0) and BCR value of 0.97 (<1). This means that the Depo is not financially to operate. With financial support from the local government for investment, the Depo can feasibly work (NPV value = IDR26,193,368.50 and BCR value = 1.01).

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