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Analytical Approach Towards Integrated Solid Waste Management: The Case Of Sidoarjo City Indonesia

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Abstract

Solid waste has evolved into a worldwide issue that must be addressed in a comprehensive and coordinated manner. Solid trash creation continues to rise in tandem with population growth, but an imbalance in infrastructure, a scarcity of land for final disposal sites, and the high cost of waste collection and transportation have all become issues in solid waste management. Sidoarjo city is likewise dealing with this issue right now. The total waste product of Sidoarjocity generated is 1,240 tons / day but only 30.2% (375 tons / day) of waste is processed in TPA 3R (reduce, reuse and recycle) and TPST Jabon, while 27.6% (343 tons / day) of waste sorting into waste banks, collectors, TPS and waste transport fleets. The government of Sidoarjo wants to reach its trash reduction goal through community-based solid waste management (CBSWM). This main research focus conducted into alternative of CBSWM under processing of composting, recycling and refuse derived fuel method (RDF) which necessary to know the potential capacity of TPST-TPA Jabon. This research is based on qualitative approach including literature review and field observation and interview. The research found that Sidoarjo City's TPST-TPA Jabon for composting can produce 42,731 kg of compost per day. Meanwhile, for the recycling process, it is capable of processing 29,803 kg / day of waste that is ready to be sold to collectors based on its type. As for the RDF process capable of managing plastic waste amounted to 51,651 kg / day and residual waste produced by 24 m^3/ day, which will be sent to landfill. Jabon landfill operational activities requiring a total of 191 workers with total area of operational and operational support facilities needed to reach 3689m^2. It canconclude from observations that various factors influence the efficacy of community-based solid waste management through TPS3R programs in Sidoarjo City.

Keywords: Solid waste management, reuse, compost, recycle, refuse derived fuel

Introduction

Solid waste management is becoming a worldwide issue that requires a holistic approach. The unbalanced quantity of infrastructure, the lack of land for final disposal locations, and the high cost of garbage collection and transportation created issues in solid waste management. To decrease the pressure on final disposal locations, trash must be handled and processed at the source (landfills)(Wilson et al. 2012). Develop the 3R technique (reduce, reuse, recycle) at the community level. The Indonesian government is now facing this issue. Aside from these issues, the federal government has set a goal of universal sanitation by the end of 2019. The government wants to reduce waste by using community-based solid waste management(Maryanti 2017; Shekdar 2009).

Many efforts were made to limit waste output at the municipal, national, and international levels. But, especially in cities, rising solid waste creation is outpacing improving solid waste management facilities and land availability for final disposal. Constructing landfills far from the city is difficult due to lack of land and environmental concerns (Memon 2010). So reducing garbage at source reduces the pressure on eventual disposal sites.

Indonesia's urban population is growing at 56.4% from 121 million in 2010 to 154 million in 2020, with over half (53.4%) living in metropolitan areas due to rising urbanization (Worldometers, 2022). Indonesians generate 0.76 kilogram of solid trash every day, with an annual growth rate of 2-4 percent (Bank 2016). Every day, 257 million individuals generate 195,000 tons of garbage. In 2015, about 71 million tons of MSW were produced. Sidoarjo is the nearest city from Surabaya which claim as the productive city in term of industrial activity. Sidoarjo population growth of 1.66% per year, which bigger than Indonesia annual rate. Another fact, Sidoarjo produced waste that is expected reach 4,400 m^3/day within the new waste transportation services raised as big as 1,240 m^3/ day.

The central and local governments must fund the execution of solid waste management in Sidoarjo, according to Act No. 18 of 2008. The local government has authority and duty in management, and implementation and operation may involve community groups, NGOs, or business sector partners. Community initiatives in solid waste management reduced garbage generation more effectively. To promote the active engagement of the public and private sectors as managing partners, the Ministry of Public Works and Housing Regulation No. 21 of 2006 states that community-based solid waste management (CBSWM). CBSWM is important in Indonesia since it is low-cost and involves considerable public engagement. The society has already proven capable of successfully implementing numerous programs, especially when they were involved from the start. Community-based solid waste management can help enhance solid waste management in residential areas by empowering local groups. One of the classifications is to handle the concept of reusing, composting, recycling and implementing of refuse derived fuel (RDF)(Caputo and Pelagagge 2002; Hoang and Fogarassy 2020; Manczarski et al. 2017; Materazzi et al. 2015).

Based on the total waste product generated per day of 1,240 tonnes / day, only 30.2% (375 tonnes / day) of waste is processed in TPA 3R (T) and TPST Kawasan, while 27.6% (343 tonnes / day) of waste is sorted. in waste banks, collectors, TPS and waste transport fleets. Planning for the implementation of TPST TPA Sidoarjo to alternate CBSWM concept aims to reduce the waste that coming the TPA3R so that it can extend capacity while shoring some waste products. So far, the dominance of waste entering the TPA comes from garbage by households and offices. Based on the above problems, waste processing will be carried out in an integrated manner to manage the 522 tonnes / day waste originating from the waste that will be transported to the TPA, the management plan is carried out because there is still potential for recycling which can generate economic value and can also be used as alternative energy management.

Literature Review

Municipal solid waste (MSW) is defined as all household and non-hazardous solid wastes, including street sweepings and construction wastes. A growing trash generation, a restricted municipal budget, and a lack of understanding by government officials about issues that influence solid waste management at all levels are among the many challenges municipalities confront today, especially in developing nations(Abdoli, Rezaei, and Hasanian 2016; Reddy et al. 2017). So, an integrated approach is required to properly collect, treat, and dispose of solid waste.

Integrated and Sustainable Waste Management (ISWM) consists of numerous waste system elements such as solid waste creation, collection, transfer, transport, disposal, and recycling. An enabling environment supports effective and sustained change (UNEP 2009). A project is considered successful if it can adapt to changing social, economic, and environmental situations. Technical and environmental issues of integrated and sustainable solid waste management(Memon 2010; UNEP 2009). According to Zurbrügg et al. (Zurbrügg et al. 2012), project success or failure is determined by:

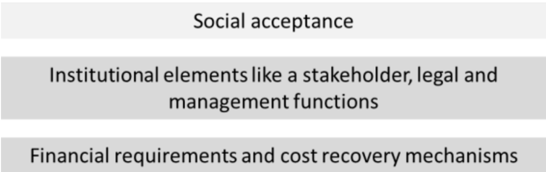

Figure 1. Three parameters considering the waste management system(Zurbrügg et al. 2012)

According to Mem on (Memon 2010), the 3R method (reduce, reuse, and recycle) attempts to maximize solid waste management from all waste producers (municipal, construction, industry, agriculture, and health facilities) (waste producers, service providers, regulators, government, and society). Because 3R helps reduce the amount of garbage dumped from source to final disposal, waste management becomes more effective, reducing environmental and public health risks. This strategy originates because many developing countries' present rubbish collection is cost constrained. When creating a landfill outside of town, it is difficult to acquire enough property to serve as a dump due to transportation costs and environmental impacts. So early waste reduction is the key. Less waste means less work for waste collection, processing, and disposal services.

However, only 30% -60% of total municipal solid waste or less than 50% of the population is handled by the SWM budgets in developing countries, according to the World Bank (Memon 2010). People in industrialized countries must cooperate to minimize waste collection costs and facilitate recycling. Because most revenues go towards garbage collection, it is difficult for many countries to provide effective treatment and disposal without external support (Jamshaid 2021; Memon 2010). This public awareness campaign supports the 3R philosophy of reducing waste generation and recycling. It is possible to develop and implement a 3R ISWM at the municipal level if the local authorities can offer trash collection and management. These are the characteristics of solid waste in developing nations(Ministry of public works 2018).

Local or national economic conditions influence waste composition. The proportion of recyclable waste (paper, plastic, etc.) is fairly high in developed countries, while high-degradable organic waste dominates in low-income countries. Recycling's poor market value is connected to low recycling rates in developing countries(Abarca, Maas, and Hogland 2012).

By definition, recycling is the process of collecting and processing garbage to create a new product that may be used again by the community and save the environment (Chang et al. 2005). A waste recycling program could help alleviate the pressure on landfills. The waste recycling technique was initially adopted in industrialized countries to reduce, reuse, and recycle solid waste. Recycling can reduce solid waste to landfills by 15-20%(Daskalopoulos, Badr, and Probert 1998). Participation, awareness, and collaboration of the community help garbage recycling programs succeed in industrialized countries (Shekdar 2009). In contrast, in underdeveloped countries, recycling is done to benefit the local economy. Not only a total waste product from the residential activity, but the construction product also needs to be considered as the main aspect materials(Indra Komara, Taşkin, et al. 2017; Indra; Komara, Wahyuni, et al. 2017; Komara et al. 2018; Komara, Wahyuni, and Suprobo 2016; I. Komara, Wahyuni, and Suprobo 2017; Wahyuni, Suswanto, and Komara 2015). The use of material or waste product also consider as the alternative to lessen the environmental impact (Pertiwi, Komara, and Fristian 2021; Susanti et al. 2021).

Research Methods and Analysis

This study used a questionnaire sample survey as a quantitative research method within a data collection followed by the analysis. Statistical methods analysis used in term of collecting data during survey to create a representative sample.

Mass balance analysis is used to determine the amount of waste which can later be reduced to TPST TPA after going through the MRF and DRF processes, the results of this analysis are used to calculate land requirements for each process in the TPST TPA Jabon.

Table 1. Recovery Factor for Waste

No.	Type of waste	Composition (%)	Wet Weight (Kg/day)	Recovery Factor (%)	Recovery (Kg)	Residue (Kg)
1	Leftover food	67,73%	353.794	69	244.118	109.676
2	Plastics	12,36%	64.564	50	32.282	32.282
3	Diapers	9,33%	48.736	0	-	48.736
4	Paper	4,95%	25.857	50	12.928	12.928
5	Residue	1,43%	7.470	0	-	7.470
6	Cloth	1,32%	6.895	25	1.724	5.171
7	Wood	0,97%	5.067	10	507	4.560
8	Glass	0,65%	3.395	65	2.207	1.188
9	Farm	0,44%	2.298	69	1.586	712
10	Plastic bottles	0,39%	2.037	50	1.019	1.019
11	Rubber	0,15%	784	25	196	588
12	Cans	0,15%	784	80	627	157
13	B3	0,14%	679	0	-	679
	Total	100%	522.359		297.192	225.167
					57%	43%

The recovery factor (RF) value of waste from Sidoarjo reaches the highest percentage of 80% for canned waste, while for the smallest RF value is 0% for types of B3, Residue, Diapers. For the type of B3 waste, the RF value is 0% because the TPST TPA does not have a permit to manage B3 waste. Meanwhile, for diaper waste and residue, the RF value is 0% because the TPST TPA does not have an effective and efficient method for this type of waste. As for the remaining percentage (amount of waste) from the value of RF will be disposed of to the TPA. The concept of integrated waste processing which is planned includes sorting the incoming waste to separate the composition of the waste by type. From this sorting process, the amount of organic and inorganic waste will be determined. From organic waste, we separate the amount of waste that can be used as compost and residue that will be disposed of to the TPA. Meanwhile, inorganic waste which is still of economic value, or which is still saleable for sale will be collected and sold to local dealers and for plastic waste will be used as fuel.

Research Methods and Analysis

Waste Processing Plan - Composite

Composting is carried out on types of waste that are categorized as organic waste, in this case components that can be used as compost, namely vegetable scraps, food scraps, fruit scraps, garden waste.

Table 2. Calculation of Organic Waste Weight

Type of waste	Wet Weight (Kg/day)	Moisture content(%)	Moisture content(kg/day)	Dry Weight (Kg/day)
Leftovers	353.794	70,00%	247.656	106.138
Farm	2.298	70,00%	1.609	690
	Total			106.828

Value of dry weight obtained from the reduction between wet weight and moisture content, because most types of waste that enter the TPST TPA are wet, the dry weight value is sought first to be used as data on the amount of organic waste that can be used as compost.

Table 3.Organic Waste for Compost

Type of waste	Dry Weight (kg/day)
Leftovers	106.138
Farm	690
Total	106.828
40%	42.731

Table 4. Density and Volume of Organic Waste

Type of waste	Dry Weight of waste (Kg/day)	Density (kg/m³)	Volume (m³/day)
Organic waste (leftovers and garden)	42.731	150	285

Table 4.Tools Needed for Compost Compost

Compost processing machine	Capacity (kg/hour)	Unit needed	Amount of land needed (m^2)
Compost Capacity	42.731 kg/day	-	-
Compost Capacity /hour	5.341	-	-
Working hours	8	-	-
Machine capacity mixer and crusher	1000	5	19,27
Granulator machine capacity	1200	4	36,6
Rotary dryer andcoller machine capacity	1200	4	25,6
Packaging (capacity 25kg/sack)	1.709 sacks//day	-	100

Total	-	13	181,47

Total organic waste (food and garden waste) that goes into the TPST TPA for compost is 106,828 kg / day, but in the compost processing process microbial processes occur. - Microbes in the compost using oxygen will break down organic matter into CO2, water vapor and heat. After some of the material has broken down, the temperature will gradually decrease. When the compost ripens, the volume and biomass of the material will shrink. This reduction can reach 40% of the volume / weight of the initial material, so the total compost waste is 42,731 kg / day.

The total volume of organic waste is known from the multiplication result of the dry weight of the waste and the density of organic waste, where from these calculations it is known that the volume of waste reaches 285 m^3.

The amount of land required is known from the dimensions of each compost processing machine multiplied by the number of units needed, for the dimensions of each lat required for compost processing as follows:

a. Mixer size = 0.82 mx 0.47 m
b. Granulator = Dimensions: Parabola = 3 m
c. Total Dimensions: 3 mx 3 mx 3.3 m
d. Rotary dryers and coolers 8 m long with 0.8 meters in diameter

For the dimensions of compost storage, it is known from the calculation of the volume of compost produced (m3) / pile height (m), in which compost will be packed using plastic bags with a thickness of 15 cm, and a maximum of 10 piles of compost sacks so that;

1) compost Volume (m3) / stack height (m)
2) 284, 87 m3(0.15 mx 10)
3) 284, 87 m3:1,5 m
4) 18.9 m2 20 m2

Waste Processing Plan - Composite

Waste recycling is specifically for types of waste that still have a use value for materials that are returned and an economic value.

Table 4. Recycled Waste

Type of waste	Trash Et Weight (Kg/day)	Density (kg/m³)	Volume (m³)	Volume after the carried out pressing	Bakcontainersto lug
Paper	23.271	30	776	388	39
Woven	690	30	23	11	1
Wood	253	150	2	2	0,17
Glass	2.207	50	44	35	4
Plastic Bottles	2.037	30	68	48	5
Cans	666	60	11	9	1
B3	679	45	15	15	2
Total	29.803	-	939	508	51

For the value of recycled waste reaching 29,803 kg / day of waste that is ready to be sold to collectors with the types of waste that have been separated from one another. To sum like container note of the amount of waste volume after compacted divided by the optimal capacity of the basin container (10 m2),for the volume of waste after compacted obtained from the volume of waste is divided Factors compaction of each type of waste, where the number of tools used to compaction over 2 units, 1 unit for paper and cloth and 1 unit for plastic bottles and cans. Meanwhile, for the glass crusher there is 1 unit.

The volume of waste is known from the wet weight of the waste multiplied by the density factor of each type of waste, then for the compaction factor of each type of waste are as follows:

a. size of the container: P = 3.6 m L = 2.3 m T = 1 , 55m
b. Container volume: 12.8 m2 with an effective volume of 10 m^2
c. Size of compacting machine: P = 1.5 m, L = 0.9 m, T = 2.5 m
d. Glass chopping machine: P = 1 m, L = 0.6 m, T = 1.25 m
e. Paper compacting factor = 50%
f. Wood Compaction Factor = 0%
g. Glass Compaction Factor = 80%
h. Fabric Compaction Factor = 50%
i. Plastic Bottle Compaction Factor = 70%
j. Cans Compaction Factor = 80%
k. Compaction Factor B3 = 0%

The can is compacted while the glass is shredded. The results of this processing of cans and glass bottles will be taken to the user for other processing and recycled. Meanwhile for B3 there is no compaction result because the TPST TPA does not have a permit for the Management and Processing of B3 waste / waste. So the type of B3 waste / waste is handed over to a 3rd party who already has a permit for the management and processing of B3 waste / waste.

The land area for the recycling of 424.23 $m^2$to land the following known Overall
Overall width = land for recycling + Land for workers (150% recycled land)
= 424.23 + 636.345
= 1060.75 m2

Waste Processing Plan –Refuse Derived Fuel (RDF)

RDF is a waste processing technology to become a renewable technology with RDF as raw material which is waste that cannot be recycled and has no economic value.RDF processing is planned as follows:

Table 5. Plastic Waste for RDF

Type of waste	Wet weight of trash (Kg/day)	Density (kg/m³)	Volume (m³)
Plastic	51.651	50	1.033

a. Crusher with dimensions 1.02 mx 0.63 m
   with a capacity of 3000 kg / hour. The land needed for the crusher machine
   = 1.02 mx 0.63 m

= 0.642 m^2
It is planned to use 2 crusher units so that the area needed for the crusher machine + land for workers
= 2 {0.642 m^2 + (150% x 0.642 m^2)}
= 3.21 m^2

b. RDF Container
Dimensions 10 mx 6 mx 3 m
Capacity 5000kg / hour. The land required for RDF storage
= 10 mx 6 m
= 60 m^2
It is planned to use 1 container unit so that the area needed for RDF Containers + land for workers
= 60 m^2 + (150% x 60 m2)
= 150 m^2

c. Furnace / dryer oven
Use dryer / oven for briquette products as follows
Dimensions 370 cm x 60 cm x 110 cm. With a capacity of 1 ton. The area required for the oven
= 370 cm x 60 cm
= 2.22 m^2
It is planned to use 1 unit of combustion stove / oven
Burning stove + land for workers
= 2.22 m^2 + (150% x 2.22 m^2)
= 5.55 m^2

d. The total area of land required for processing at RDF
= Area for Crusher + RDF storage area + Land for burning furnace / Dryer oven
= 3.2 m^2 + 150 m^2+ 5.55 m^2
= 158.75 m^2

The Residue Transport, following is the number of trucks required for a fixed container system. Generation residue sent to landfill of 24 m^3/ day. Counting the number of trips / day (Tchobanoglous et al):
The number of trips / days = 1.7 trips / day ≈ 2 trips / day
operating time = number of trips / day x time trip = 1.7 trips x 1 hour = 1.7 hours
Garbage truck required 2 units

This section demonstrates how the contribution rates derived in this study can be used to estimate the cost of material wastes in building projects. Although some residual level of construction waste is unavoidable, the correlation between waste and cost minimisation is substantial and provides an incentive for participants in construction projects to pursue them. The total cost of waste is the sum of its materials and disposal costs.

Rates of contribution basically based on waste levels which are calculated to find out the volume of waste of each material that has previously been determined using pare to analysis. Below is the example of calculation of waste level in the material attached to the steel rebar Ø8-plainaccording to Indonesian Standard . Normally, a single steel rebar Ø8-plain is having 12 m long which equivalent to 4.74 kg and then easily determined by ;
Used Volume = 1,062 rods (obtained from warehouse reports) equivalent to 5,033.88 kg

Installed Volume = 4,277.57 kg
Volume Waste = Used Volume – Installed Volume
Volume Waste = 5,033.88 kg – 4,277.57 kg = 756.31 kg
Waste Level = (Volume Waste) / (Used Volume) x 100%
= 756.31/5,033.88 x 100% = 15.02 %

Extent to the contribution, waste cost calculation then followed by the waste cost analysis. The following calculation of waste cost in the material obtained by the considering contract obtained from secondary data of some companies which valued by Rp 3,250,336,000. Following calculation can be identified as informed below;
Workload = (Amount of Material Price)/(Total Contract Value) x 100%
Material Price = Vol Used x Unit Price
Material Price Amount = 5,033.88 x Rp 12,000 = Rp 60,406,560
Workload = (Amount of Material Price)/(Total Contract Value) x 100%
Workload = (Rp 60,406,560)/(Rp 3,250,336,000) x 100% = 1.86%
Waste Cost = Waste Level x Workload x Total Contract Value
= 0.1502 x 0.0186 x Rp 3,250,336,000 = Rp 9,075,717.50

Labour and supporting facilities

The calculation of labour is adjusted to the addition of tools and the amount of garbage. The calculation consists of the calculation of labour for waste sorting, compost packaging, sale-worthy waste packaging and machine operators. The calculation of labour estimates are as follows:

Table 6. Evaluation of labour due to waste management

No	Labor	Reception	Sorting	Recycling (packaging)	Compost	RDF	Total
1	OperationalManager			1			1
2	Technical Manager			1			1
3	Power Picker on the conveyor		67				67
4	Power Packaging of goods stalls			67			67
5	Power packaging compost				10		10
6	Power and operator RDF					4	4
7	Operator Equipment and Engineering	1	1	1	1	1	5
8	Operator and supervision weighing	1		1	1		3
9	The driver of truck			20			20
9	Administration	1		1	1	1	4

10	Security	4	4
11	Park officers and cleaning	4	4
12	K3 officers	1	1
	Total		191

a. The office
Space functions as an administrative activity for TPST TPA. The office space is planned to be occupied by 6 employees consisting of Operational Managers, Technical Managers and administrative officers. With an area of 3.7mfor administrative officers2, and for managers 5 m2. Area of Office Space = Area of space for Admin + Room for Manager = (4 x 3,7m2) + (2 x 5 m2) = 24,8 m2
b. Multipurpose room (meetings)
for visitors or guests with a maximum capacity of 30 people + 5 facilitators from the landfill, with the amount of space for the ballroom is 1,05m2 per person then, Total space Serbguna = maximum capacity of the room x amount of space per visitor = 35 people x 1.05 m2/ person = 36.75 m2
c. Prayer room
It is planned to have a maximum capacity of 40% of the total number of employees at TPST TPA Jabon with an area of 2 m2/ person, then,
Prayer room area = prayer room capacity x space per person = (40% x 191) x 2 m2= 152.8 m2
d. Rest Room
It is planned to have a maximum capacity of 70% of the total number of employees at TPST TPA Jabon with an area of 2 m2/ person, thus,
the area of the rest room = the capacity of the rest room x the area of the room per person = (70% x 191) x 2 m2= 267.4 m2
e. First aid room
It is planned to be a place for first aid for workers in case of undesirable things as well as a working space for K3 officers, with a first aid room planned for 12 m2.as well as a work space of 3.7 m2 , the area of the first aid room = first aid room + work space for officers = 12 m2 + 3.7 m2= 15.7 m2
f. Toilets
according to the Minister of Labor Regulation No. 7 of 1964 concerning Health, Cleanliness and Lighting Requirements in the Workplace The number of toilets is as follows: for 1 - 15 workers = 1 toilet, 16 - 30 = 2 toilets, 31 - 45 = 3 toilets, 46 - 60 = 4 toilets, 61-80 = 5 toilet, 61-100 = 6 toilet and thereafter for each 100 workers should be provided at least six toilets, with each toilet consists of 2 bathrooms and 2 washbasins, with an area per toilet 12m2 then
Size toilet toilet x = Number Size Per toilet = {(191: 100) x 6} x 12m2= 144 m2
g. Generator Room
Generator room is used as a place to store and operate the generator and its repair as a backup power source for TPST TPA Jabon operations. The planned Gen set Room is 18 m2 with dimensions of length x width of 3 x 6 m.
h. Warehouse
The tool warehouse area is used as a place to store tools for TPST TPA needs. It is planned that a tool warehouse of 12 m2 with dimensions of length x width is 3 x 4 m.
i. Guard Post

This guard post is placed at the entrance which functions to regulate the entry and exit of garbage transporting vehicles. With a planned land area of 2 m3/ officer,
area of guard post = number of officers x area requirement per officer= 4 people x 2 m2= 8 m2

j. Land Parking
Requirements for Land at TPST TPA are classified into 2, the need for parking space for workers and the need for visitors, for parking space requirements for workers it is assumed as follows:
70% depart by foot / hitchhike / deliver
5% of the workforce using a car = 9 cars
25% using a motorbike = 48 motorbikes

k. While the need for parking space for visitors, it is assumed that every month the TPS TPA receives a visit of 50 people assuming 1 bus, 2 cars and 5 motorbikes. Meanwhile, the total number of trucks totaling 22 units, with each parking space requirement of 11.5 m2 for cars, 1.5 m2 for motorbikes, and 40.8 m2 for buses / trucks. Then the amount of parking space required is as follows: Land area for cars = Number of cars x Unit of parking space for cars = (9 + 2) x 11.5 m2= 126.5 m2
Land area for motorbikes = total number of motorbikes x units of parking space for cars = (48 + 5) x 1.5 m2= 79.5 m2
The land area for the Bus for the need for parking space for the bus will be placed in the parking for the transport truck fleets. Land area for the Truck = Number of trucks x parking space units for the bus = 22 x 40.8 m2= 897.6 m2. So that the total parking area required is = land area for cars + land area for motorbikes + land area for trucks = 126.5 m2 + 79.5 m2 + 897.6 m2= 1.103.6 m2.However, from the total land requirement for the parking area, only parking space for cars and motorbikes (206 m2) is in the form of a building, while trucks are placed on open land with paving mats.

l. Maintenance room and truck repair shop. a building without a partition with maintenance space is planned for 10 x 15 mplanned2, while for the workshop a maximum capacity of 2 vehicles is, the Maintenance Room and the Truck workshop: = Mantenance space + Truck Workshop Area = 150 m2 + (2 x 40, 8 m2) = 231.6 m^2

m. Park
Planned for the park is an area of 10% of the total building area at TPST TPA Jabon apart from parking for trucks, then. Park Area = Total building area x 10% = 2537,795 m2 x 10% = 253.78 m2

Table 6.Total Land Requirements

No	Space	Land Requirment(m^2)
1	Compost Management	
	Equipment for composting	181,47
	Compost storage	20
2	Recycling Management	
	Land for recycling	424,23
	Land for workers	636,345
3	RDF	
	Land for Crusher	3,2
	Containment area for RDF	150
	Land furnace /Dryer oven	5,5

No	Space	Land Requirment(m^2)
4	Supporting Facilities	
	Office	24,8
	Multipurpose room	36,75
	Mushollah	152,8
	Breaking room	267,4
	First aid room & officers	15,7
	Toilet	144
	Generator room	18
	Warehouse	12
	Guard Post	8
	Parking area	1103,6
	Maintenance Room and Truck repair shop	231,6
	Park	253,78 m^2
	Total Building Area	2.537,795 m^2
	Total Land Area	3.689,175 m^2

Conventional waste processing carried out by workers found the level of exposure to dust was 0.9 mg/m3 (range = 0.05 to 4.51 mg/m3), the exposure level to endotoxin was 1123 EU/m3 and the level of exposure to bacteria and fungi exceeding 104 (CFU)/m3 (Park et al., 2011). In another study, the level of exposure received by workers was 0.3 mg/m3 for dust, 27.7 EU/m3 for endotoxin, 13,000 CFU/m3 for fungi and 1800 CFU/m3 for bacteria (Scholosser et al., 2015). So we need worker-friendly technology, namely DRF and MRF. The results of gas composition from DRF emissions, namely CO, H2, and hydrocarbon gas products are influenced by the type of raw material but can be minimized by air control devices (Win et al., 2019; Materazzi et al., 2016). In addition, RDF is able to reduce humidity from 22.9% to 1.4% and increase the calorific value from 19.6 to 25.3 MJ / kg, so I recommend this method as an additional energy source (Bialowiec, Andrzej. at all. 2017; Caputo and Pelagagge. 2002; Dong and Lee. 2009; Ouda et al., 2017).

DRF operational costs range from Rp. 282,031.20 to Rp. 354,675.60 per Mg (1 Mg = 1 metric ton) of waste generates electricity ranging from 4.7 to 7.8 kWh per Mg of waste (Phillip et al., 2015). Cement giants Holcim and La Farge, use DRF as an energy source with a composition comprising about 10% of DRF and the remaining 90% (Sapuay. 2016). MRF can reduce the operational costs of solid waste management, by expanding the landfill and changing the route of waste transportation to be more efficient (Chang et al., 2005; Citrasari et al., 2010). The MRF in Peganden Indonesia is able to process 898 kg/day of waste and the remainder is transported to the TPA of 1,207 kg/day (Driananta and Ellina. 2017). The use of MRF is able to provide a payback period of 10 years with a return of 20.5% (Franchetti. 2019).

Conclusion

From a total of 1,240 tonnes / day of landfill in Kab. Sidoarjo still has 522,359 kg / day left that has not been processed so that it is planned to be processed at the TPST TPA Jabon. From this amount, the residue from recovery factor processing is 225,167 kg / day or 43% of the total amount of initial waste that enters, with the highest recovery factor value for canned waste by 80%. The processing of waste produced by TPST TPA Jabonis capable of producing compost of 42,731 kg / day, while the value for recycling of waste reaches 29,803 kg / day, while for RDF it reaches 51,651 kg / day. The residue is sent to the landfill by 24 m3/ day. To carry out the entire operational process, TPST TPA Jabon requires 191 workers with an area of land for operations and the required operational support facilities reaching 3,689.175 m2.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

REFERENCES

Abarca, Lilliana, Ger Maas, and William Hogland. 2012. 'Solid Waste Management Challenges for Cities in Developing Countries'. WASTE MANAGEMENT.

Abdoli, M. A., M. Rezaei, and H. Hasanian. 2016. 'Integrated Solid Waste Management in Megacities'. 2(3):289–98.

Bank, Asian Development. 2016. Indonesia Country Water Assessment.

Caputo, Antonio C., and Pacifico M. Pelagagge. 2002. 'RDF Production Plants : I Design and Costs'. 22:423–37.

Chang, Ni-bin, Eric Davila, Brian Dyson, and Ron Brown. 2005. 'Optimal Design for Sustainable Development of a Material Recovery Facility in a Fast-Growing Urban Setting'. 25:833–46.

Daskalopoulos, E., O. Badr, and S. D. Probert. 1998. 'An Integrated Approach to Municipal Solid Waste Management'. 24:33–50.

Hoang, Nguyen Huu, and Csaba Fogarassy. 2020. 'Sustainability Evaluation of Municipal Solid Waste Management System for Hanoi (Vietnam)— Why to Choose the " Waste-to-Energy " Concept'. 1–20.

Jamshaid, Iqbal. 2021. 'Best Practices of Solid Waste Management at Institute Of'. Journal of Sustainability Perspectives 1(1):193–99.

Komara, I., E. Wahyuni, P. Suprobo, and K. Taskin. 2018. 'Assessing the Tensile Capacity of Cold-Formed Steel Connections Using Self-Drilling Screws and Adhesive Materials'. International Journal on Advanced Science, Engineering and Information Technology 8(2).

Komara, I., Endah Wahyuni, and Priyo Suprobo. 2017. 'A Study on Cold-Formed Steel Frame Connection : A Review'. IPTEK, The Journal for Technology and Science 28(3):83–89.

Komara, Indra;, Endah; Wahyuni, Priyo; Suprobo, and Kivanc Taskin. 2017. 'Experimental Study of Adhesively Bonded Connection Strength in Cold-Formed Steel Roof Truss Connection'. Pp. 1–4 in Regional Conference in Civil Engineering (RCCE) The Third International Conference on Civil Engineering Research (ICCER).

Komara, Indra, Kıvanç Taşkin, Endah Wahyuni, and Priyo Suprobo. 2017. 'Experiment on Cold-Formed Steel C-Section Joint With Screw Ond Adhesive Material'. MATTER: International Journal of Science and Technology 3(2):51–63.

Komara, Indra, Endah Wahyuni, and Priyo Suprobo. 2016. 'Studi Numerik Perilaku Sambungan Baut Dan Adhesive Pada Struktur Rangka Atap Baja Ringan'. Pp. 1–9 in Konferensi Nasional Pascasarjana Teknik Sipil (KNPTS).

Manczarski, Piotr, Janusz Gołaszewski, Andrzej Białowiec, Jakub Pulka, and Paweł Ste. 2017. 'The RDF / SRF Torrefaction : An Effect of Temperature on Characterization of the Product – Carbonized Refuse Derived Fuel'. 1–10.

Maryanti, Dewi Fitria. 2017. 'Performance of Community-Based Solid Waste Management for Integrated and Sustainable Solid Waste Management. The Case of Bogor City, Indonesia'. (49947).

Materazzi, M., P. Lettieri, R. Taylor, and C. Chapman. 2015. 'Performance Analysis of RDF Gasification in a

Two Stage Fluidized Bed – Plasma Process'. WASTE MANAGEMENT.

Memon, Mushtaq Ahmed. 2010. 'Integrated Solid Waste Management Based on the 3R Approach Integrated Solid Waste Management Based on 3R Approach'. Journal of Material Cycles and Waste Management (March):1–25.

Ministry of public works. 2018. Environmental and Social Management Framework.

Pertiwi, D., I. Komara, and R. Fristian. 2021. 'Design Concept of Reinforced Concrete Beams with Large Web Openings'. IOP Conference Series: Materials Science and Engineering 1010:012039.

Reddy, K. Yugandhar, Narasa Raopet, I. Srinivasa Reddy, Associate Dean Academics, and Andhra Pradesh. 2017. 'AN ANALYTICAL APPROACH FOR ENVIRONMENTAL POLLUTION CONTROL THROUGH SOLID WASTE MANAGEMENT : A MODEL STUDY'. 8(11):579–90.

Shekdar, Ashok V. 2009. 'Sustainable Solid Waste Management : An Integrated Approach for Asian Countries'. Waste Management 29(4):1438–48.

Susanti, Eka, Heri Istiono, Indra Komara, Dewi Pertiwi, and Yanisfa Septiarsilia. 2021. 'Effect of Fly Ash to Water-Cement Ratio on the Characterization of the Concrete Strength'. IOP Conference Series: Materials Science and Engineering 1010:012035.

UNEP. 2009. D EVELOPING I NTEGRATED S OLID W ASTE M ANAGEMENT P LAN. Vol. 4.

Wahyuni, Endah, Budi Suswanto, and Indra Komara. 2015. 'Effects of Angle of Inclination Cables on The Performance of Submerged Floating Tunnel Under Hydrodynamic Load'. Pp. 15–26 in The 5th Environmental Technology and Management Conference "Green Technology towards Sustainable Environment.

Wilson, David C., Ljiljana Rodic, Anne Scheinberg, Costas A. Velis, and Graham Alabaster. 2012. 'Comparative Analysis of Solid Waste Management in 20 Cities'.

Zurbrügg, Christian, Margareth Gfrerer, Henki Ashadi, Werner Brenner, and David Küper. 2012. 'Determinants of Sustainability in Solid Waste Management – The Gianyar Waste Recovery Project in Indonesia'. 32:2126–33.