Pit Composting Methods for Community Based Waste Treatment (A Case Study in Ngadimulyo Village)

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Submission date: 18-Mar-2023 04:57PM (UTC+0700)
Submission ID: 2039954877
File name: PROSID_C.17.pdf (992.39K)
Word count: 3895
Character count: 18427

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To cite this article: S Sumiyati *et al* 2020 *J. Phys.: Conf. Ser.* **1655** 012124

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Abstract. The estimated municipal solid waste produced in Temanggung District is 486.8 tons/day, with a large composition of organic waste, which is around 70% of the total waste generation. Community participation in village waste management is a form of community institutional strengthening in the village waste management. A waste management plan is needed as a program to create a zero-waste society in Ngadimulyo Village. This study aims to analyze the potential and existing conditions of waste management and plan a pit composting system for waste management. The technique used in this study is a survey, composting test, making compost pits that after this called *kowen* or pit composting, and testing the maturity of compost. Better waste management can be developed with operational engineering sub-systems and the application of appropriate technology.
Key Words: pit composting, zero waste movement, waste management,

1. Introduction

Waste management is a global challenge, especially economically in developing countries, because of their population growth, lifestyle changes, increasing people's living standards, and increasing waste generation [1]. Poorly managed domestic waste includes a lack of sanitation and inadequate services. Waste management facilities in developing countries have produced severe environmental pollution impacts, damage to the landscape, and even have a negative influence on the health of the local community [2]. Public awareness in Indonesia to manage their waste is relatively low. Based on the 2018 Indonesian Environmental Statistics released by the Central Statistics Agency (BPS), only 1.2% of households recycle their waste [3]. Around 66.8% of households handle waste by burning. The smoke generated from combustion can cause air pollution and interfere with health. While as many as 32% of families choose other ways to handle their waste, such as dumping waste on empty land and rivers.

Community participation in village waste management is one form of strengthening the institution of community waste management. Waste management in villages is often neglected because village problems are considered not as complicated as urban waste problems. That perception causes issues that are getting bigger by time. Management of organic waste through fertilization and landfill is a method of waste management that can cause air and groundwater pollution problems [4]. Therefore, community participation is needed in tackling organic waste in rural areas. Temanggung Regency is one of the regencies in Central Java with large plantations, and the majority of the domain is still rural. According to data released by the Environment Agency of Temanggung Regency, the estimated waste produced is 486.8 tons/day. The Temanggung Government can only handle 15.83% of the total waste generation through its current waste handling program every day. The composition of organic waste is the most generated waste, about 70% of the entire waste generation. Most of the organic waste is dumped directly into empty land.

The Temanggung village was given an essential role in realizing one of the three leading programs of the Temanggung Regency Government, namely to create a waste management program, zero-waste village. One form of handling organic waste in rural areas is by making compost pits with a composting process that involves the community in its implementation. An organic waste management plan is needed as a program to create a zero-waste village in Ngadimulyo Village. The management made requires data on the number of residents and the amount of waste generated by each house. The evaluation of the organic waste composting method will be implemented in all villages in Temanggung Regency. Still, no communities have been used as pilot projects for other villages to achieve this organic waste management. Therefore, there is a need for an organic waste management design appropriate to the situation in the villages in Temanggung District based on community participation. This study aims to analyze the potential and existing conditions of waste management in Ngadimulyo Village to plan a composting system using the pit composting method for organic waste management in Ngadimulyo Village.

2. Research Methods

2.1. Methods
Pit composting methods is a method of composting organic material into soil holes with a hole size of 1 m x 0.5 m x 0.5 m. Several adjacent compost pits are made to transfer organic material to the next pit. Usually, 2-3 times moved the soil pit can already be harvested with compost. The ground floor of compost pits is often given clay to reduce the potential of groundwater pollution. Organic material is placed in a compost pit in layers [5]. Organic waste that will be used for research needs to be tested in advance the fundamental characteristics of the solid waste in the form of test levels of Carbon (C), Nitrogen (N), Phospor (P), Potassium (K), C/N ratio, water content, pH, and temperature. After the waste has been chopped, the waste is measured for its weight and water content. Waste is weighed according to the required weight of 30 kg, then put into the reactor, and MOL is added to the waste pit in reactors B and D while stirring. The addition of microorganisms is done once every seven days.

In this study, four treatment reactors were used, namely uncovered and without local microorganism (MOL) compost as a control reactor, and three comparator reactors consisting of uncovered compost and given MOL, compost closed and without MOL, and compost closed and offered MOL Table 1 below shows the variation of composting treatment comparisons.

Table 1. Treatment variation

Reactor	Composition	Treatment
A	30 kg of household	Without local microorganism (MOL) and closed system
B	waste	With local microorganism (MOL) and unclosed system
C (Control)		Without local microorganism (MOL) and unclosed system
D		With local microorganism (MOL) and unclosed system

2.2. Organic-C Test
Organic C-test is done by weighing 0.5 grams of sample, then putting it into 100 ml measuring flask, then adding 5 ml of K_2CrO_7 1 N with a pipette, then shaking it. After that, 7.5 ml of concentrated H_2SO_4 is added and stirred until an orange-red color is obtained, then allowed to stand for 30 minutes until the solution cools. After that, dilution is done by adding distilled water to the mark marks and let it cool. The next day, the absorbance of a clear solution was measured using a spectrophotometer at a wavelength of 561 nm.

C-organic levels (%) = ppm curve x ml extract 1000 ml^{-1} x 100/mg samples x fk

= ppm curve x 100/1.000 x 100/500 x fk
= ppm curve x 0,02 x fp x fk (1)

Additional Information :

pm curve = sample level obtained from the curve of the relationship between the standard series level and its reading after being corrected blank.
100 = conversion factor (%)
fp = dilution factor (if any)
fk = moisture content correction factor = 100/(100-% water content)

2.3. Total Nitrogen Test

Nitrogen testing is done by weighing 0.5 grams of sample, then put into a digestive tube. Add 1 gram of mixture and 3 ml of concentrated sulfuric acid, destined to a temperature of 350°C (3-4 hours). Destruction is complete when white steam comes out, and a clear extract (about 4 hours) is obtained. The tube is removed, cooled, then diluted with distilled water to 50 ml. Beat until homogeneous, leave overnight so that the particles settle. Add 6% NaOH to neutral pH. Extracts are used to measure nitrogen by distillation or colorimetry and then diluted using distilled water up to 25 ml. Add 1-2 drops of Siegnette salt reagent using a pipette. Then 0.5 ml of Nessler reagent is added, then shaken and left for 10 minutes. The intensity of the yellow color is measured with a spectrophotometer at a wavelength of 420 nm.

Nitrogen Levels (%) = ppm curve x ml extract 1000 ml^{-1} x 100/mg samples x fp x fk
= ppm curve x 50 x 1.000^{-1} x 100/500^{-1} x fp x fk
= ppm curve x 0,01 x fp x fk (2)

2.4. Total Phosphorus Test

The Phosphorus test is carried out by weighing 1,000 grams of the pulverized sample into an Erlenmeyer, adding 10 ml of HNO_3, shaking, and leaving it overnight. Then heated to the digestor block starting with a temperature of 100°C, after the yellow steam runs out, the temperature is raised to 200°C. Destruction is terminated when white steam comes out, and the liquid in the flask is left around 0.5 ml. Then cooled and diluted with H_2O to an exact volume of 50 ml, shaken until homogeneous, left overnight, or filtered with filter paper W-41 to obtain clear extract (extract A). Then test the sample by taking 1 ml of extract A using a pipette into a 10 ml measuring flask. Next, added one drop PP indicator and 40% NaOH until pink color arises. Add 2 ml of vanadate reagent to the measuring flask and dilute using distilled water until the mark. Allow 15-25 minutes, then measure with a spectrophotometer with a wavelength of 420 nm and record the absorbance value.

Equation : $$\text{mg P/L} = \frac{mg\ P(in\ 10\ ml\ samples)\ x\ 1000}{ml\ samples} \quad (3)$$

2.5. Potassium Test

Potassium test is done by taking 1 ml of extract A using a pipette into a 20 ml volume chemical tube, adding 9 ml of distilled water, shaken with a vortex mixer until homogeneous. This extract is the result of dilution of 10 times (extract B). Measure K in extract B using the SSA method (Atomic Absorption Spectroscopy) with a standard series of mixture I as a comparison.

2.6. Scoring Parameter

Scoring is done based on ranking, the maximum score is given to the variation that has the best rating, and the minimum score is given to the changes that are not good [6]. Each composting parameter will be tested, scoring based on SNI 19-7030-2004 [7]. Scoring was modified so that it has 11 criteria. A value of 0 to 10 is given to the parameters, while 0 means not meeting the requirements. Then, the subject's score in each setting is summed to become the subject's cohesiveness score.

3. Result and Discussion

3.1 Analysis of Existing Organic Waste Conditions in Ngadimulyo Village
The integrated waste management system has not yet been fully implemented in Ngadimulyo Village. Most Ngadimulyo villagers still manage waste individually. However, some villagers in Ngadimulyo, such as Ngadiprono and Gintung Hamlet, have achieved their waste. Gintung Hamlet is a waste management system with a communal pit in one *dasawisma* (a local women community consisting of 20 houses) separated between organic and inorganic waste. Likewise, in Ngadiprono Hamlet, sorting order and organic waste and inorganic waste have been implemented. The organic waste management system in Gintung and Ngadiprono Hamlet can be seen in Figure 1. Every day, Ngadimulyo Village produces 720.26 kg of waste consisting of 404.98 kg of organic waste and 315.28 kg of inorganic waste. This waste is dominated by domestic waste originating from residents, commercial facilities, and educational facilities.

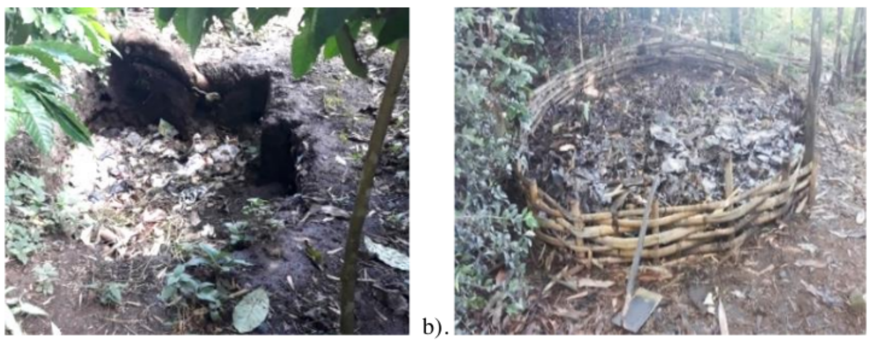
a). b).


Figure 1. Organic waste treatment in Ngadimulyo Village(a) Communal composting pit Gintung Hamlet; (b) Waste sorting and waste management in Ngadiprono Hamlet

3.2 Analysis of Household Domestic Waste Composting
3.2.1. Temperature. Temperature measurements are carried out every day for 28 days with an alcohol thermometer. From day 0 to day 12, the temperature of the entire reactor exceeds the requirements of mature compost in SNI 19-7030-2004, which means a decomposition process occurs [7]. The temperature rise is caused by the activity of mesophilic bacteria in degrading organic matter. The temperature of the entire reactor has met the standard, which is the maximum compost temperature of 30^{o}C. This value is per Widiarti (2015) opinion that the compost temperature is initially high and will experience a continuous decline until stable [8].

3.2.2. pH. The pH measurement is done once every two days for 28 days. In this study, pH was fluctuating in the range of 7-8 until the 28th day. The nature of the composting material causes this pH change, i.e., vegetable waste, which has a pH of 6-7, and the activity of microorganisms that form organic acids. The entire pH of the reactor meets SNI 19-7030-2004, i.e., and the maximum pH is 7.49. This result is consistent with the opinion of Chen et al. (2015) that the optimal pH value is 5.5 – 8 [9].

3.2.3. Organic Carbon (Organic-C). C-organic measurements were carried out on days 0, 7, 14, 18, 21, and 28th day spectrophotometrically with a wavelength of 561 nm. The highest C-organic level is reached on day 0 because compost has not undergone a decomposition process, so microbes do not use the energy contained in the fertilizer. Reactors given MOL have higher C-organic content. C-organic content is fluctuating but decreases on the 28th day because microbes use carbon to degrade organic matter. This result is in Pratiwi (2013) 's opinion that the levels of C-organic in compost will decrease because microorganisms break down into simpler compounds [10]. All reactors on the 14th day until the 25th day met the mature compost requirements in SNI 19-7030-2004, namely the minimum C-organic content of 9.8% and the maximum limit of 32%.

3.2.4. Total Nitrogen. Nitrogen measurements were carried out on days 0, 7, 14, 21, and 28th day spectrophotometrically with a wavelength of 636 nm. Nitrogen levels affect the C/N ratio of compost produced. The highest levels of nitrogen are achieved on two different days. This increase occurred because, at the end of composting, nitrifying bacteria remodel the organic material from ammonia to nitrate [11]. In this study, Nitrogen levels are fluctuating and tend to fall because excess nitrogen is used as a food source for microorganisms [12]. Nitrogen levels of all reactors on the 7th day and 21st day are not by SNI 19-7030-2004, namely a minimum Nitrogen level of 0.4%, but on the 0th, 14th, and 28th days are met.

3.2.5. C/N Ratio. The C/N ratio is obtained from the calculation of C-organic levels divided by Nitrogen levels. The sequence of reactors with the highest C/N ratio is reactor A (88.49%), reactor C (74.79), reactor B (64.76%), and reactor D (61.31%). The higher the C/N ratio, the more difficult the material to decompose. The C/N ratio has decreased on the last day. According to SNI 19-7030-2004, the optimal C/N ratio is in the range of 9.8-20%.

3.2.6. Total Phosphorus. Phosphorus measurements were performed on days 0, 7, 14, 21, and 28th day spectrophotometrically with a wavelength of 400 nm. Nitrogen levels influence phosphorus levels. The higher levels of nitrogen, the higher the levels of Phosphorus [12]. The highest phosphorus level occurred on the 14th day, while on the 28th day, there was a decrease. Phosphorus content in all reactors, as per the requirements of mature compost in SNI 19-7030-2004, has a minimum phosphorus content of 0.1%.

3.2.7. Total Potassium. Potassium measurements were performed on days 0, 7, 14, 21, and 28th of the AAS (Atomic Absorption Spectroscopy) method. The lowest potassium levels occur on day 0 because there has not been a weathering process by microorganisms. Reactors A and B had the highest potassium levels on the 7th day, while reactors C and D had the highest potassium levels on the 21st day. The most optimal composting occurs on the 7th day. Potassium content in all reactors as per the requirements of mature compost in SNI 19-7030-2004, i.e., the minimum potassium content is 0.2%. Data obtained during composting can be seen in Table 2.

Table 2. Recapitulation of research data during composting

Day	Treatment	Parameter						
		C (%)	N (%)	P (%)	K (%)	C/N Ratio	Temp. (°C)	pH
0	A	35.41	0.562	5.131	0.204	64.83	40	7.50
	B	45.89	0.650	5.191	0.256	61.31	40	7.50
	C	32.12	0.563	6.207	0.304	74.79	39.5	7.50
	D	42.93	0.649	6.060	0.199	66.43	39	7.50
7	A	26.26	0.283	4.538	1.022	88.49	40	7.50
	B	17.44	0.659	4.894	1.940	64.76	31.5	7.25
	C	35.42	0.393	12.267	0.388	63.26	39.7	7.25
	D	35.51	0.111	10.973	0.494	46.79	36	7.50
14	A	21.85	1.100	12.553	0.468	54.15	30	7.00
	B	35.46	0.457	11.537	0.608	28.62	30	7.50
	C	13.78	0.432	8.865	0.776	24.53	30	7.50
	D	18.16	0.452	11.329	0.561	18.22	30	7.25
21	A	13.85	0.355	2.015	0.584	45.21	27	7.75

Day	Treatment	Parameter						
		C (%)	N (%)	P (%)	K (%)	C/N Ratio	Temp. (°C)	pH
	B	24.98	0.369	1.956	0.373	46.36	27	7.25
	C	32.13	0.291	2.617	1.040	59.82	27	7.25
	D	23.56	0.323	2.997	1.725	49.87	27	8.00
28	A	20.53	0.421	3.914	0.262	54.15	25	7.50
	B	11.70	0.639	4.948	0.146	28.62	25	7.25
	C	12.02	0.526	2.582	0.128	24.53	25	7.25
	D	20.68	0.576	2.371	0.217	18.22	25	7.25

3.3 Determination of the Most Optimal Compost Based on Scoring

Based on the recapitulation of the scoring calculation, it is obtained that the highest value is found in reactor C with a score of 113, and the lowest-scoring result is in reactor D with a score of 98. This result shows that the C reactor with a composition of 30 kg of domestic organic waste without treatment produces the highest scoring calculation if compared to other reactors.

Table 3 Recapitulation of the scoring results

Treatment	Scoring Days					Total
	0	7	14	21	28	
A	12	23	24	20	23	102
B	12	22	24	24	23	105
C	22	10	27	30	24	113
D	12	14	27	23	22	98

The domestic sector produces waste of 0.48 kg/household/day with a volume of 0.0027 m^3/household/day, commercial facilities provide waste 0.07 kg/household/day with a size of 0.0003 m^3/day, and educational facilities produce 1.02 kg/household/day with a volume of 0.0047 m^3/household/day. Next, an analysis of the communal pit calculation was carried out so that the results obtained were pit having a size of 0.25 m^3 with dimensions of 1 m x 0.5 m x 0.5 m. Based on the sampling results, the amount of organic waste produced by the Papringan Market is ± 100 kg/day, with a volume of 0.7 m^3. Thus, the results obtained are pit has a size of 1 m^3 with dimensions of 1 m x 1.5 m x 0.5 m. *Kowen* built for Ngadimulyo Village in 2020 is 507 pits, where one communal pit is for ten families, and each communal pit used requires composting time for two weeks to process. So, it takes at least three communal beds for ten families.

4. Conclusion

The absence of integrated waste management that integrates all aspects of waste management in Ngadimulyo Village forms the basis of this research. The majority of Ngadimulyo Village residents still manage their waste individually. The composting method used is a pit method with a composting time of around 2-3 weeks. For each *dasawisma* (10 houses), a communal pit is built with three pits with a size of 1 m x 0.5 m x 0.5 m. For all villages, 507 communal pits and two pits for Papringan markets need to be built in 2020.

Acknowledgment

The authors would like to acknowledge the Faculty of Engineering, Universitas Diponegoro, for funding this research by RKAT scheme Fiscal Year 2020 Number 2496/STL07/UN7.5.3.2/PP/2020.

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