Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2015.20.1.59

Effect Various Combination of Organic Waste on Compost Quality

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Received 13 October/ accepted 30 December 2014

ABSTRACT

Municipal solid waste and agricultural waste have different ratio C/N and nutrients contents. They can be used as compost row materials. The purpose of the research was to get an optimum combination of both wastes to improve compost quality, to meet the Indonesian National Standard 19-7030-2004. Composting process use pots. The treatments were twelve combination of municipal solid waste (garbage market, household waste, restaurant waste) and agricultural waste (rice straw, empty fruit bunches of oil palm, cassava peel, banana skin) with a ratio of 1:1 and enriche by chicken manure, cow manure, wood ash and cellulolytic microorganisme. The treatment were replicated three times. The results showd that the nutrients content of compost were 0.77 to 1.19% nitrogen, 0.23 to 0.30% phosphorus, 0.46 to 0.69% potassium and 15.48 to 34.69% organic matter. The combination of agricultural waste and municipal solid waste affected the quality of compost. Compost that meets SNI 19-7030-2004 is a combination of rice straw+market waste that contains 1.12% nitrogen, 0.28% phosphorus, 0.63% potassium, ratio C/N 19.50, pH 7.42, and organic matters 37.65%.

Keywords: Agriculture compost, compost, ratio C/N, organic waste

INTRODUCTION

Now a days the existence of municipal solid waste and agricultural waste is still a problem in Indonesia. Those wastes need to be managed properly. The strategy to be implemented in the management of those wastes are to reduce the volume of the waste and to get the added value of the waste. One alternative to manage that through composting, because it can be used as organic fertilizer for plant.

However, the quality and the decomposition time of the compost variety according to the type of compost materials and the organic matter decomposers. The activity of decomposers affect nutrient cycling processes in the composting. Biological decomposition is due to the activity of microorganisms and the results are new material as a relatively stable humus (Ismayana *et al.* 2012). Lately, the agricultural and urban wastes are used and considered as a source of organic matter, because it can produce a lot of biomass and also easily obtained. Processing of organic municipal waste and agricultural waste into compost can increase the soil productivity, as well as one alternative to support agricultural and urban waste management.

The study was aimed to determine the best compost composition resulted from the municipal solid waste and agricultural waste that fulfilled the compost quality according Indonesia to National Standards (SNI).

MATERIALS AND METHODS

Study site

This research was conducted in the technical implementation unit of Agricultural Faculty Bina Widya Campus, University of Riau. Compost from municipal solid waste obtained from market, household, and restaurant. Agricultural wastes were rice straw, empty fruit bunches of oil palm, cassava peel and banana skin.

Research experiment

This study used a completely randomized design consisting of 12 treatments of compost combinations in 3 replications so that there were 36 experimental units. The treatments were K1= paddy straw+market waste, K2= paddy straw +Household waste, K3= paddy straw +restaurant waste, K4= paddy straw + market waste, K5= empty fruit bunches of oil palm + household waste, K6= empty fruit bunches of oil palm + restaurant waste, K7=cassava peel+ market waste, K8= cassava peel + household waste, K9= cassava peel + restaurant waste, K10=banana peel+ market waste, K11= banana peel + household waste, K12= banana peel + restaurant waste.

Composting Process

Firstly, compost materials were cut approximately 5 cm with a ER3 thrasher types, then moisture content of the material were determined to calculate the need of the materials in each experimental unit. Next step was weighing the raw material according to the treatment with the ratio of 1:1 and then the material mixed by stirring with add-on material. The add-on materials of nutrient compost were 10% chicken manure, 5% cow manure, 1% ash wood charcoal and 1% cellulolytic microorganisms (0.5% of *A. niger* and 0.5% of *A. flavus*) of the weight of the compost material. All the ingredients are homogeneously mixed and then put in plastic pots of 30 cm × 40 cm and each experimental unit was filled with 2 kg of materials then the pot was covered with black plastic. Each experimental unit was labeled and arranged according to the research lay out. Temperature and moisture content of compost materials were maintained during 7 days of composting process and watering the pot was done when the moisture content was less than 70%.

Data Variables

The observations were made to temperature changes during composting. The physical condition of compost at the end of composting process (color, smell, structure), physical analysis of compost (moisture content and material shrinkage compost), chemical analysis of compost (pH, C-organic, total N, P and K). Chemical analysis of compost was done by moist extraction, N (Kjeldahl), C-organic (Walkley and Black), P (Spectrophotometer) and K (Flame photometer).

RESULTS AND DISCUSSION

Characteristics of Organic Waste

The organic raw materials of agricultural waste and municipal solid waste had high ratio C/N, water content and carbon (Table 1). The combination of compost materials might create ideal conditions for microorganisms in the metabolism of complex organic materials into simpler compounds. Optimal compounds consent in compost materials, such as carbon as a source of energy and nitrogen for protein synthesis, will make faster the composting process (Nur 2008).

Table 2 shows that there is a temperature difference between treatment in the first week. The increase temperature was shown in a combination of compost (empty fruit bunches of oil palm waste + city waste + rice straw) which of 29.13-32.47 ^{o}C while the combination of compost (cassava peel + municipal solid waste, municipal solid waste + banana peel) was below 29 ^{o}C. This was likely due to the enzyme substrate reacted with microorganisms (which will be in the relegation molecule) to form a bond of simple enzyme (Anwar *et al.* 2004). Increasing the temperature in the first week in which microorganisms multiplied rapidly and break down complex compounds into simpler compounds of organic material. Organic matter has decomposed, then the temperature will decrease until it reaches normal temperature. Weeks 2 and 3 the temperature ranged of 26.5-29.5 °C began to decrease. The next week of 4 and 8 the temperature began to decrease approaching soil temperatures.

Enzyme reactions resulting from *A. niger* and *A. flavus* produced optimal temperature ranged of

Table 1. Characteristics of organic waste

Compost material	Water content (%)	C-organic (%)	N (%)	Ratio C/N
Empty fruit bunches of oil palm	76.50	56.97	1.05	54.26
Paddy straw	60.60	43.03	1.47	29.27
Cassava peel	78.80	54.99	0.77	71.42
Banana peel	74.80	37.99	1.33	28.56
Market waste	81.20	50.25	2.52	19.94
Household waste	62.40	43.51	1.4	31.08
Restaurant waste	70.20	57.37	1.12	51.22

Table 2. Compost temperature during the composting proses on week I-VIII

Compost treatments	Weeks							
	I	II	III	IV	V	VI	VII	VIII
	....			(^{0}C)		....		
K1	29.13	28.03	27.43	26.93	27.00	26.93	26.68	26.53
K2	31.53	29.23	27.47	26.63	27.03	26.97	26.73	26.47
K3	30.67	28.17	26.67	26.67	26.80	26.80	26.67	26.56
K4	31.20	28.50	28.43	27.43	27.90	27.60	27.43	27.37
K5	32.47	30.03	28.83	27.57	28.03	27.77	27.33	26.83
K6	30.93	29.13	28.07	27.47	27.83	27.67	27.43	27.13
K7	28.00	27.93	28.00	26.73	27.13	26.63	26.50	26.45
K8	28.53	27.90	28.10	27.20	27.33	27.23	26.90	26.50
K9	28.47	27.77	27.57	27.27	27.30	27.57	27.37	27.28
K10	26.87	26.67	26.67	26.73	26.67	26.83	26.83	26.80
K11	26.93	26.33	26.60	26.33	26.53	26.73	26.83	26.73
K12	28.33	27.57	27.60	27.10	27.27	27.10	27.20	27.17

K1=Paddy straw+market waste, K2= Paddy straw +Household waste, K3= Paddy straw +restaurant waste, K4= Paddy straw + market waste, K5= Empty fruit bunches of oil palm + Household waste, K6= Empty fruit bunches of oil palm + restaurant waste, K7=Cassava peel+ market waste, K8= Cassava peel + Household waste, K9= Cassava peel + restaurant waste, K10=banana peel+ market waste, K11= banana peel + Household waste, K12= banana peel + restaurant waste.

25-37 ^{o}C. The difference of the average temperature of the compost material in the first was due to particle characteristics of materials, in which particles of oil palm empty fruit bunch compost and rice straw were greater than the banana and cassava peel skin, so that the air circulation, and it generated more higher heat. Research finding by Anwar *et al.* (2004), paddy straw substrate using *A. niger* produced higher cellulase enzyme activity and productivity than corn substrate at 30 ^{o}C .

The final temperature of all treatments full filled Indonesian Standard quality compost. This suggests that the composting material has entered the final stages of composting. The temperature in this study was the optimum temperature for the used isolates. Kusumaningrum *et al.* (2010), *A. flavus* growth and development depended on the environment, such as temperature (25-35 ^{o}C) .

Chemical Characteristics of Compost

After week 8, the laboratory tests to determine the chemical characteristics of compost were done. Based on Table 3. it can be seen that the organic matter content of rice straw compost + household waste, cassava peel + household waste compost was lower than the others. All combinations of organic waste meet Indonesian standard of SNI 19-7030-2004 compost, except compost of oil palm empty fruit bunches + waste that exceeded the market standard compost. This was likely due to the microorganism activity to break down carbon compounds as a source of energy and release carbon dioxide into the air perfectly. The longer the fermentation, C-organic content will decrease due to being reformed into simpler compounds by microorganisms (Ismayana *et al.* 2012). If superdec bioaktivator is used in composting, it can speed up the composting process with declining rate of C/N ratio of 62-75% within 7-21 days of incubation (Goenadi and Santi 2006).

Carbon changes according to Ismayana *et al.* (2012), a decomposition process of carbon during composting is due to decomposition of organic matter by microorganisms in which the carbon is consumed as an energy source by releasing CO_2 and H_2O for aerobic processes so that the concentration of carbon is reduced. While the change in the total N of compost is used as components of microbial protein in the formation of body cells for proliferation. The measurement of the N total compost showed different results for 8 weeks.

The highest nitrogen content was in (1.19%) the combination of palm empty fruit bunch compost bins + market, phosphorus content (0.30%) was in compost + cassava peel waste market, whereas potassium contant (0.69%) was in cassava skin compost household waste, when compared to Indonesian standard SNI 19-7030-2004 quality

Table 3. Chemical Composition of Compost from varions combination of organic waste

Description:K1=Paddy straw+market waste, K2= Paddy straw +Household waste, K3= Paddy straw +restaurant waste, K4= Paddy straw + market waste, K5= Empty fruit bunches of oil palm + Household waste, K6= Empty fruit bunches of oil palm + restaurant waste, K7=Cassava peel+ market waste, K8= Cassava peel + Household waste, K9= Cassava peel + restaurant waste, K10=banana peel+ market waste, K11= banana peel + Household waste, K12= banana peel + restaurant waste.

compost, compost has a combination of all standards. Nitrogen content appeared higher than the phosphorus and potassium, this is due to more microorganisms break down the amino acids in the protein into nitrogen and more active if the greater number of microorganisms in the compost. The increasing in some types of nutrients in the remains body of microorganisms, especially nitrogen (N), phosphorus (P) and potassium (K) will run better with the number of microorganisms that play a role (Nasrul and Maimoon 2009).

The phosphorus element content will be higher by the occurrence of weathering of organic matter into compost. Maturation levels of microorganisms and phosphor content in the mix microorganisms in the compost will directly improve the content of phosphorus in compost (Nasrul and Maimun 2009). The results of Kasli (2008), composting of the *T. harzianum* produced P elements of 1.20% compared to the granting of earthworms P elements (0.95%).

Compost contained a nutrient such as nitrogen, phosphorus, potassium plays a role in plant growth. If the initial organic material used to manufacture contained enough N compost, usually the other nutrients such as phosphorus and potassium will be available in sufficient amounts (Pramaswari *et al.* 2011).

Initial moisture content of the waste treatment combination is different in all the combination with average of 60-70%. This is due to the organic material is still fresh. Composting for 8 weeks showed a decrease in water content in all waste combinations with an average of 25-47%. Decompositions of organic materials such as proteins, starch, hemicellulose, cellulose, lignin, etc., will break down complex compounds into simpler compounds and it requires water (H_2O) derived from compost materials. Stirring regularly during 2 weeks may reduce the water content in the mound. Moisture reduction may occur as a result of a given air supply which will be able to open up the space between the phases in the mound. Mounds can evaporate the water so that up to 8 weeks the water content will be reduced. Moreover pot used as a composting site can allow air and moisture to pass, because it has small holes under the base pot. Too low or too high water content will reduce the efficiency of the composting process. It moisture content exceeds 80%, the air volume is reduced, the smell will be generated from the compost because oxygen levels are insufficient for metabolism so that activity in the composting process is hampered and eventually become anaerobic. While the water levels are too low means the humidity below 40% will decrease microbial activity and it will lower the humidity of 15% (Yenie 2008).

The combination of raw material waste compost banana peels + cities showed that a decrease in water content is higher than the other compost materials, it is caused by the characteristic of banana skin which is more soft and higher water content. Stirring regularly performed 2 weeks may reduce the water content of the compost. Moisture reduction may occur as a result of a given air supply is able to open up the space between the phases in the compost. Besides, used a potting compost can allow air and moisture to pass, because it has a small hole in the bottom of the pot.

pH of rice straw compost + market waste compost was significantly different with cassava peel + restaurant waste. The pH value of the combination of rice straw + market waste meets Indonesian National Standard SNI 19-7030-2004 . This is due to the organic material of organic compounds of overhauled nitrogen produced enough organic acids and cations (K^+ ,Ca^+, Mg^{2+}) and it is released a little (Khaerunnisa and Rahmawati 2013) so that after 8 weeks of composting the pH toward neutral.

The increase in pH is caused by the activities of microorganisms that transform organic nitrogen compounds (amino acids, amides, ammonium compounds, nitrates, etc.) into ammonia. Cations will bind the acids formed in the process of composting, such as forming KNO_3 causes the pH to rise. Research of Nur (2008), the use of cellulolytic bacteria and bacterial decomposers xylanolitic for rice straw decomposition indicated the degree of acidity of pH values of all inoculant treatments during decomposition ranged of 8.45-8.74 pH (alkaline) .

Alkaline pH conditions have a good impact in the decomposition. This is evident from the research Khaerunnisa and Rahmawati (2013), using calcium hydroxide ($Ca(OH)_2$) in citrus waste composting by adjusting the pH level of the substrate from acidic to become alkaline, thereby lignin, and cellulose become easier to break down by cellulolytic microbes.

During composting, nitrogen mineralization is occured in which changing of organic nitrogen into ammonia which causes the pH value increases, while the decrease in pH caused by the increase production of organic acids or nitrification process (Zaman and Sutrisno 2007). Changes in pH value is also influenced by the exchange of ammonium ion (N- NH_4^+). The decrease in N-NH_4^+ is a good indicator of maturity and composting (Khaerunnisa and Rahmawati 2013). Generally, compost decomposition process will always produce a neutral pH and is stable at the end of composting when compared to the standard quality of compost Indonesia SNI 19-7030-2004 (Table 4) .

Based on Table 4, for all combinations, the produced chemical content of compost meets the standards, in contrast to the pH of the compost exceeds SNI 19-7030-2004 standards. This is due to the presence of microbial activity in compost produce ammonia. The highest C/N ratio is in the combination of oil palm empty fruit bunches + household waste (Table 2) because it has a high cellulose and lignin so that decomposition is slow.

Microorganisms decompose organic matter rapidly when the C/N ratio of 30/1 is stable in comparison. When the C/N is too high decomposition is running slow. When the C/N ratio is too low, many nitrogen content and the nitrogen is enable to lost to the atmosphere in the form of NH_3 gas causing odor problems. Compost C/N is not high either used at the plant or at the time of the directly application to the plant. It will be competition between plants with microbes in the process of absorption of available nutrients in the soil (Pramaswari *et al.* 2011).

Physical Characteristics of Compost

Based on Table 5. it can be seen that there are differences in the initial weight of compost, this is due to the influence of the water content of different materials. The highest weight was at + initial composting banana peels litter the market (3,958 kg), the lowest weight was + cassava peel waste restaurant (3,558 kg). While the highest weight on the end of the composting was + cassava peel + restaurant waste (1,846 kg), the lowest was banana peel + restaurant waste (1,133 kg). This is due to overhaul of microorganisms in the compost, then the size of the compost materials turn into tiny particles, which can cause piles to shrink the volume

Table 4. Compost Quality according to Indonesian Standards SNI 19-7030-2004.

Limit	Organic matter (%)	Nitrogen (%)	C/N	Fosfor (%)	Calium (%)	Water content (%)	pH
Min	27	0.4	10	0.1	0.2	-	6.8
Max	58	-	20	-	-	50	7.49

Table 5. Physical characteristics of compost from various combination of organic waste.

Parameter	Unit	Treatments											
		K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12
Initial weight	Kg	3.080	3.733	3.567	3.822	3.753	3.587	3.793	3.724	3.558	3.958	3.889	3.723
Final weight	Kg	1.433	1.466	1.473	1.570	1.616	1.620	1.680	1.686	1.846	1.166	1.170	1.133
Depreciation	%	53.47	60.73	58.70	58.92	56.94	54.84	55.71	54.73	48.12	70.54	69.91	69.57
Colour		SB	SB	SB	SB	SB	SB	SB	SB	SB	BB	BB	BB
Constraction		SC	SC	SC	SNS	SNS	SNS	SC	SC	SC	SC	SC	SC
Physic		SS	SS	SS	S	S	S	SS	SS	SS	S	S	S

Description:K1=Paddy straw+market waste, K2= Paddy straw +Household waste, K3= Paddy straw +restaurant waste, K4= Paddy straw + market waste, K5= Empty fruit bunches of oil palm + Household waste, K6= Empty fruit bunches of oil palm + restaurant waste, K7=Cassava peel+ market waste, K8= Cassava peel + Household waste, K9= Cassava peel + restaurant waste, K10=banana peel+ market waste, K11= banana peel + Household waste, K12= banana peel + restaurant waste. SC (Soil constraction), SNS (Start not smell), BB (Blakish brown), Soil black (SB), S (Smooth), SS (Similar soil).

and approximately half the weight of compost will be decreased during decomposition (Cahaya and Nugroho 2009).

Depreciation of municipal solid waste compost organic + farm waste on average of 48-70%, indicating decomposition by microorganisms uses the carbon and nitrogen as an energy source and water is lost into the air intake of compost material, causing the compaction of material structure, loss of pores so experiencing shrinkage (Nur 2008). The combination of banana peels + organic municipal solid waste was significantly different with all the combination treatment of depreciation compost. Provide the highest shrinkage 68-70%, this is due to a decrease in water content is higher than the other compost materials.

Nur (2008) stated the decomposition of cellulose, hemicellulose, fats, lignin release carbon dioxide (CO_2), water and heat energy, causing weight and content of the basic raw materials of compost will be reduced to 40-60 % and depends on the basic raw materials of compost and composting process. Depreciation heavily influenced by the composting microorganisms that break down organic material with the help of oxygen to produce H_2O, CO_2, nutrients and energy. The overhaul of the structure of the material compaction occurs, the loss of pore water and air storage so that raw materials are composted severe shrinkage.

The color changes to black due to the formation of more humic compounds (Nur 2008) . Change the color to black indicating compost already had a change of physical maturity of compost. Compost does not smell the odor of late composting, compost odor which smells like soil, it is caused by bacteria that are able to separate the components of carbon C, hydrogen (H), Oxygen (O_2), nitrogen (N) and Sulfur (S) that is the components of the waste so it does not cause odor (Indrawati et al. 2013). The results showed that the change in color, odor, texture combination meets the Compost Quality of Indonesian Standards SNI 19-7030-2004.

CONCLUSIONS

Based on the results of this study, it can be concluded that the combination of organic municipal waste and agricultural waste compost resulted is different qualities. Compost Quality Standards that appropric with Indonesia SNI 19-7030-2004 was found in rice straw compost bins + market which indicated the highest value of N 1:12 %, 0:28 % P, 0.68 % K, 37.65 % organic ingredients, the lowest C/N 19.5, and pH 7.42; while physical characteristics of compost is black like soil, ground and flavored crumb texture.

ACKNOWLEDGEMENTS

This study is part of research competence grant funded by DP2M DIKTI with contract No. 353 / UN.19.2 / PL2013 on behalf of Hapsoh.

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