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The Simple Machines for Making Organic Fertilizer at School

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ABSTRACT

Bio organic manure is fertilizer made from organic material (plants, animal dungs etc.) as a source of nutrient for plants. How to produce was using a simple technology, the material needed was Effective Microorganism (EM) as biodecomposter in fermenting organic material. The purpose of the study was to design a tool to make organic manure. The source of green manure was grass and leaves taken from the School of Environmental Health "Magetan", Health Polytechnic of Surabaya. The process of appropriate technology starts from copping the material (±1 cm), using 7 Pk cutting box copper, the raw material was suitable enough for the raw material of organic fertilizer. The next step is to drum the material into a digestor as a composter. To reduce the time needed for composting, it was needed additional material EM4 (Effective Microorganism) in 3 variation namely 2%, 4% and 6% with duration of 14 and 21 days. The assessment of the maturation of the organic manure based on the smell, colour, texture, pH, temperature and the result of laboratory test N, P , K C/N ratio with the duration of the fermentation process varied between 14 and 21 days. The nutrient content reference refers to SNI/2004. Result of the study about kind of garbage: grass and bushes leaves with the capacity of 5 to 20 kg/day. Tool specification mechanic chopper box consists of two components mover motor (7 PK) and box chopper (leave cutter). Digestor specification: 1 unit of iron wagon frame, 1 unit of digestor, the process of fermentation using EM4. The result of observation and measurement of temperature, pH, moisture, colour, smell, texture and grade C, N, P, K and C/N ratio qualifies SNI/2004. Fermentation process EM 2% within 14 to 21 days was the efficient result in cmpost maturation. The suggestion in this research, a further study is needed to increase the useful mechanic box chopper capacity and granulator design development to process compost into worthy compost granule, cheap MOL production, local materialand the result is better than EM4.

Keywords: Appropriate technology, Organic fertilizer, Effective microorganism

INTRODUCTION

Compost is made of the decomposed waste of living creatures (plants or animals) that runs aerobically and anaerobically which support each other in certain environmental conditions and this process is called decomposition(1). Compost undergoes a longer decomposition process (40 days) and 20 days faster when using Em4(2). The greater EM4 concentration is, the greater number of bacteria will be, so that the material are more quickly decomposed by the bacteria(3).

The process of composting can be useful for reducing the amount of organic waste and it is also safe because it is breaking the chain of disease spread and has economic value because it can be sold as agricultural fertilizer(4).

There are 60 sengon trees in the School of Environmental Health "Magetan", Health Polytechnic of Surabaya, Ø 40 to 60 cm height more than 10 m, more than 30 mango tree, tiara shrub, more than 6000 m^2green yard. Garbage from dormitories and employees potentially used as organic fertilizer (compost) that has not been utilized with appropriate technology. Aim

The purpose of this research was to design an organic fertilizer tool to produce compost in accordance with SNI / 2004. As an easy and cheap technology design, Science and Technology for Society (IbM) based, the design of this tool consists of cutting box coper of organic waste and digester which can produce compost by using dried leaves, grass and food waste.

METHODS

The experimental research using one-shot case study design[5]. The researcher design the tools, observe the process of organic waste into organic fertilizer using EM4 starter with 3 variations, 2%; 4% and 6% and each variation with 3 times replication. Assessment of the result of the organic fertilizer maturation based on odor, color, texture, pH, temperature, and laboratory test results N, P, K, C / N ratio with a fermentation process varied from 14 to 21 days.

The Method of Making Organic Fertilizer

Raw materials: organic waste (food scraps, vegetables, etc.), wet or dry leaves (sengon leaves, trembesi, lamtoro, mango, grass etc.) Supporting materials: Dolomite; Drops / sugar; Bran; Effective Microorganism (EM)4

Tools used: mechanical cutting box coper (cutting tool) with 5 PK drive machine assembled to cut the compost raw material 1 to 3 cm to accelerate the fermentation process. Digester: 50 l drum functions as a fermenter (12 pieces) equipped with stirrer and ventilation. The tool assembly can be illustrated in the block diagram below:

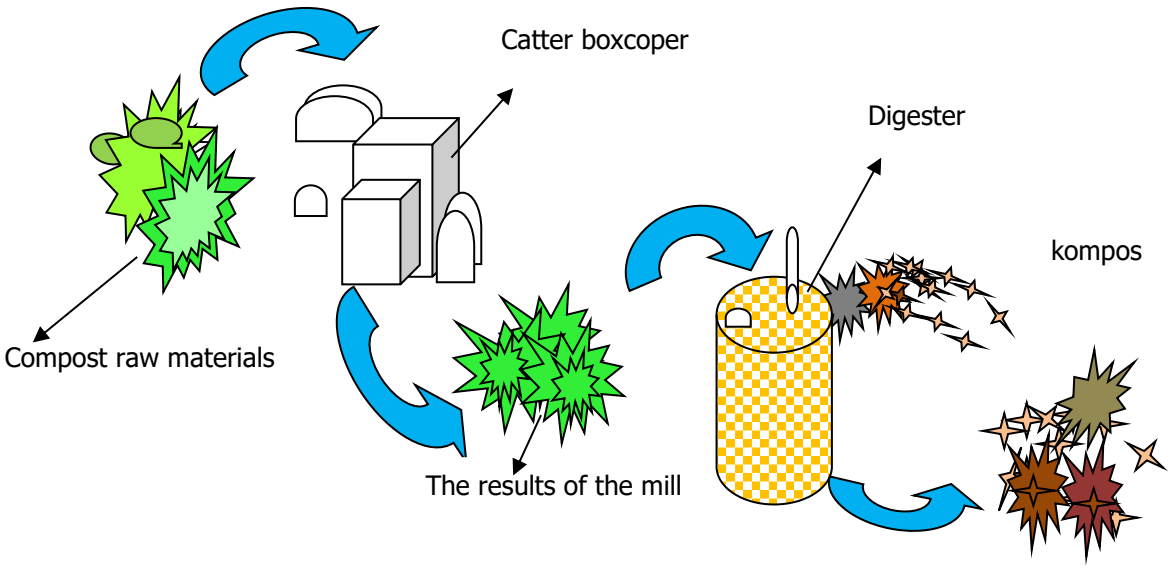

Figure 1. Composite block diagram

How to make (assumption of 100 kg):

1. Organic waste of about 100 kg is chopped in the box copper to get smaller size (1 up to 3 cm)
2. Sprinkle 3-5 kg dolomit to the chopped Organic waste evenly. Mix well.
3. After that, add about 3=5 kg.
4. Mix drops / sugar and EM4 - 1: 1, mix well.
5. Pour 2% of the mixture to the organic waste. Add sufficient water and mix evenly to moist (wet when being touched, not watery when being squeezed)
6. Then, materials are put into the digester (composting tub).
7. After 3 day - treatment, check the temperature and humidity, a good temperature indicated by maximum is 30 °C and maximum humidity is 50% RH, if more than that, do reversal action to the waste and add water if needed.
8. The reversal is done several times until it is no longer hot.
9. After 2-4 weeks, it is done and ready to use.
10. Take samples to examine the content of N, P, K, C / N ratio.
11. Repeat the procedure for EM4 (4% or 4 l) and also for EM4 (6% or 6 l)
12. Examine Physical Quality of Compost (odor, color, temperature and humidity) and chemistry N, P, K and C / N ratio (SNI / 2004)

RESULTS

Specifications Composting device

Table 1. Detailed mechanical cutting box coper tool and equipment specifications

No	Unit	Specification
1	Motor	1. Product: Matari GX200 2. Max power 7 HP 3. Fuel gasoline 4. Speed 3600 (rpm) 5. Oil capacity (0.6 l) 6. Tank capacity (3.6 l) 7. Weight (16 kg)
2	Box Coper	1. Home industry products 2. Knives 5 pairs 3. Blades 4 pairs of knives 4. Can be used as corn cobs and whore cutters.
3	Capacity	1. Cutting of leaves and grass 50 to 90 kg / h (depend on material)

Table 2. Details of digester tools and equipment specifications

No	Unit	Specification
1	Armor frame	1. Size 150 cm x 100 cm x 60 cm 2. Elbow iron 4.4.4. 3. Capacity for digester from drum material 3 pieces 4. Equipped with front and rear wheels and rotary trash mixing drive.
2	Digester	1. Drum volume 100 l of water 2. Organic waste capacity 8 to 15 kg of garbage. 3. Holes Temperature and humidity vents. 4. Equipped with wheel lockers that can be moved during garbage filtration.
3	fermentation process	1. Using EM4 Each formula 2%, 4% and 6% premises replication 3 times 2. The duration of the process (day) to become fertilizer (being tested)

Type and Capacity of Waste

The result of identification of the type of garbage made for compost was grass (70%) and other sources such as leaves from sengon, mango, tiara shrub and other shrubs and food waste (30%). The trashes were collected and then been milled in Mechanical cutting box coper and the results are ready for use as compost raw material.

Mechanism of Operation and Maintenance of Equipment Mechanical Cutting Box Coper

Formerly, mechanical cutting box coper design tool has 7 pairs of cutting knife equipped with 4 rafters and the result was compost material 1 to 3 cm. The finer compost material will be easily fermented by bacteria fermenter and composting process will be faster. It is reinforced by Rahmawati & Novriandoni (2014) stating that the finely chopped material compost will accelerate the fermentation process into compost and the addition of EM4 will shorten the compost making process[(2)].

This mechanical cutting box coper tool is able to produce 50 to 90 kg / hour to grind garbage and leaves with fuel needs (Pertalite) 0.5 to 0.75 l. The form of grinding outlet is a quarter iron plate of circle 30 cm x 40 cm and thickness of 0.8 mm. The modified one has diameter Ø 12 mm, 10 mm and 8 mm. The result is the bigger diameter hole is, the coarser garbage will be produced, and vice versa. The use of this machine is designed in accordance with the needs of the user.

The noisy sound of the machine shows the knives rotates faster. The thing to note is the suitability of the compost material that is poured, not too fast because the milled garbage will make the blockage and the machine gets heavier and the knife will stop. As a result, the belt is not able to rotate the blade of the knife shaft and the solution turns the on button to the off then it will stop. If it happens, remove the clamped garbage, and clean it slowly and carefully due to the sharp knife.

Operational Mechanisms and Digester Maintenance

Digester is a tool used for making campus waste media into compost. The equipment is 9 drums (100 liters of water) is equipped with 90 ventilation holes Ø 8 mm (temperature and humidity controller) with composting calculation using 3 EM4 variations namely 2%, 4% and 6%. The digester design is equipped with a stirring rod on the shaft connected with the rotating drive to simplify the job. By rotating the digester drum, the compost inside keep rotating and mixed automatically. The result is that the temperature and humidity of the compost material are controlled in addition to the effort to flip through the material if the temperature is too high and give the water spray slowly if it is too dry to reach the desired moisture.

Composting

Compost of Mechanical cutting box coper milling process is done by physical observation and measurement of chemicals. Duration used is 14 days and 21 days with variations EM4: 2%, 4% and 6% waste as compost material. The average result of composting on physical observation and chemical measurement is a recapitulation of the table: 3 below:

Table 3. Recapitulation results of observation of physical and chemical parameters in composting

Treatment Time	EM4 Usage	Physical parameters (average)						Chemical parameters (average)				
		Temperatur	pH	Humidity	Color	Odor	Texture	C	N	P	K	C/N
14 day	2 %	34.6	6.9	44.4	Blackish Brown	Soily Smell	Fairly smooth	23.1	1.5	0.8	2.8	15.5
	4 %	34.2	7	44.3	Blackish Brown	Soily Smell	Fairly smooth	22.6	1.5	0.9	2.4	13.1
	6 %	33.4	7	42	Blackish Brown	Soily Smell	Fairly smooth	22.2	1.6	0.9	2.4	13.2
21 day	2 %	33.1	6.9	46.1	Blackish	Soily Smell	Smooth	22.21	1.5	0.8	2.2	14.8
	4 %	34.4	7.0	45.6	Blackish	Soily Smell	Smooth	22.82	1.5	0.9	2.1	14.6
	6 %	34.4	6.9	45.6	Blackish	Soily Smell	Smooth	22.10	1.5	0.9	2.1	15.5
Control Day14	-	31.8	7	44.6	Brown like the material	A bit of smell	Coarse Like the material	-	-	-	-	-
Control day 21	-	31	6.9	46.1	Dark Brown							

Description:
The waste that does not use EM4 (Control) is not checked because physically remains the same as the ingredients

DISCUSSION

Temperature Observation

Based on the results of 28 ^{0}C temperature measurement at the beginning of the process, then slowly rises 44^{0}C at the end of the first week and the beginning of the second week. The decreased temperature happens afterward at about 31-34 ^{0}C until the maturation of the compost. According to SNI 19-7030-2004 for mature compost requirements must have the groundwater temperature because the temperature in groundwater can be absorbed by plant roots in an aerobic atmosphere and not more than 30 °C[6]. There is no significant difference from the treatment of 2%, 4% and 6% better EM4 addition both 14 and 21 days.

Decomposer microorganisms will be active at a certain temperature range (30-60 ˚C) will show fast composting process[7]. Too low or too high temperatures can cause decomposer microorganisms will not be active so that the composting process will not be perfect. Therefore, during the composting process to note the fluctuations of the temperature, because high temperatures will kill pathogenic bacteria and weed seeds. The composting process generally takes place in a combination of thermophilic and mesophilic temperatures[8].

Humidity

The result of humidity measurement Table 3 can be seen that the change of humidity occurring ranges between 40%-60% RH (fix to SNI / 2004)[6] and about compost quality standard, that mature compost criterion has maximum moisture 50% RH. This condition has been achieved at 21 days of compost (week 3). To keep the humidity remain the same is by controlling the compost at least every 2 days by doing reversal treatment to optimum conditions. There is no significant difference from the treatment of 2%, 4% and 6% EM4 addition both 14 and 21 days. Being too dry, it is necessary to spray water slowly until optimum moisture is reached. The biological reaction of microorganisms in decomposing organic matter is influenced by the content of water. Microorganisms can take advantage of organic materials when the organic material is soluble in water. On the manufacture of organic fertilizer made from household waste, the optimum range of microbes is found in 40 - 60% moisture[2].

The linkage of moisture in the composting process is the availability of oxygen for the activity of aerobic microorganisms. When the water content of the material is in the range of 40-60%, the aerobic decomposition microorganism will work optimally and cause rapid decomposition. However, if water content is more than 60%, it will cause anaerobic condition. Thus, aerobic microorganisms do not work optimally and it result in bad composting process. Meaning, the process runs slowly. Some of the process will switch to anaerobic and produce CO_2 as well as organic compounds, such as organic acids and often cause bad smell. In order not to lack oxygen, usually the pile of material reversed or by using a blower. Reversing material is done at least once a week[8].

Degree of acidity (pH)

The degree of acidity or pH in table 3 is at normal values of 6.8 to 7. And this is in accordance with SNI 19-7030-2004 on compost quality standards (6.8-7.49). Changes in odor organic matter, Color and texture on the compost of this study can be influenced by changes of pH. Increase in pH shows a number of bacteria reuse organic acid as a source of energy. With the addition of EM4 treatment (2%, 4% and 6%) does not show a significant difference in pH. The initially low pH values will rise slowly and will be constant after 21 days of treatmentThe degree of acidity (pH) is one of the factors supporting the compost maturity, the pH must be maintained in the normal range to minimize the loss of nitrogen in the formation of ammonia gas. The production of ammonia from nitrogen-containing compounds will increase the pH in the initial phase of composting and if the compost has matured it is usually close to neutral[7].

Color

The results of the color observation of the compost in the first week is still the same as the color of the original condition. This is due to the incubation period of good EM4 bacteria using EM4 2%, 4% and 6%. But at the end of the week it seems to start brownish tend to dark. The colors look different on the 14 day composting time of the decomposition process and change color to blackish at 21 days. There is a change of color during the fermentation process indicating the existence of the decomposer microorganisms work well. Other influential factors are also due to the treatment of efforts to control temperature and humidity during the process.

By considering the condition, actually, 14 to 21 day – treatment, on which the color is darken, has fulfilled SNI / 2004 requirements and ready to use for fertilizing plants[6]. In terms of color is very difficult to distinguish the color of compost fermentation day 14 and 21, no matter of addition EM 2%, EM4 4% and 6%. Because they are almost the same. While the compost color of the control is almost similar to the original color and just look more brownish-brown color.

According Priyantini (2013), the color of compost that has become groundy black both using EM4 and MOL on leaf and goat dung material at different ages[9]. Usage of EM4 changes compost with soily black color faster than using MOL. This is because the number of fermenter bacteria from EM4 is more complete than the MOL bacteria which is used.

Odor

Observation of odor at day 14 and 21 the compost smells soil (according to SNI / 2014)[6] and difficult to differentiate the usage of EM4 variation (2%, 4% and 6%). This is very different from the control compost that still smells almost the same as the original material. The appearance of odor in the composting process due to the aerobe process that produces organic waste + O2 + nutrients -→compost + new bacteria + CO_2 + H_2O + NO_3 + dead bacteria + SO_4^{2-} + heat. While anaerobe: Organic Trash + H2O + nutrients -→compost + new bacteria + CO_2 + CH_4 + NH_3 + dead bacteria + H_2S + heat. Proceeding the mature phase, the smell compost is getting like the

ground[7]. According Priyantini (2013), making leaf and goat dung compost using EM4 does not smell at time of 6 weeks[9].

Texture

The texture of the day 14 using EM4 (2%, 4% and 6%) is very difficult to distinguish physically as it starts to look smooth. The more EM4 the texture tends to bemore loose. This is predicted because the material used in this study comes from the same location although the EM4 adding process is different. At day 21 the texture of the compost looks even smoother compared to day 14. There is a relationship that the closer to day 21 of EM4 use, the smoother compost texture, the darker the color is. While the texture on the compost control until the day 21 is still similar to the original texture which is still rough and there has been no change.

The above conditions are supported by Wellang (2013) research that, to succeed in organic composting, it necessary to note the texture of raw materials[7]. The smaller size of the materials is, the faster decaying process will be. The compost texture that has been so smooth and moist are influenced by EM4 microorganisms fermenter, they are photosynthetic bacteria, Lactobacilus Sp, Streptomyceters Sp, Yeast and Actinomycetes[9].

Chemical Parameter Measurement Results

1. Nitrogen (N)

Laboratory tests of Nitrogen (N) parameters at week 2 to week 3 all meet the requirements of SNI / 2004, namely at week 2 of 1.5 -1.6% all for EM4: 2%; 4% and 6%[6]. The fermentation day of 14 and 21 does not increase the result of N. The more EM4 there is a tendency to increase N. The nitrogen content is one of the important parameters that must be in compost, because nitrogen is needed to create 1-4% dry matter (hard parts) stems, skins, and seeds. Nitrogen is taken from the soil in the form of nitrate (NO_3^-) or ammonium (NH_4^+), or in combination with carbohydrate metabolism compounds in plants in the form of amino acids and proteins.

In composting, there is a process of carbohydrates breaking down in the form of hemicellulose into CO_2 and H_2O or CH_4 and NH_3. The protein will decompose into amides and amino acids which are then converted into NH_3, CO_2 and H_2O. Mineral nutrients from organic compounds decompose into inorganic materials available in the form of ions namely the ions NH_4, NO_2 and NO_3[10]. According to Novizan (2007), Nitrogen is a major component of various important substances in plants (40-50%). Protoplasm content is the living substance of plant cells composed of nitrogen compounds. Nitrogen compounds are used by plants to form amino acids that are converted into proteins. Nitrogen is also needed to form important compounds such as chlorophyll, nucleic acids, and enzymes. Nitrogen derived from this organic material can be utilized by plants that involve the activity of soil microorganisms[11].

2. Phospor (P_2O_5)

Phospor parameters laboratory examination (P_2O_5) at week 2 and week 3 is equal. Addition of EM4 2% (0.8%) campus waste is smaller than the addition of EM4 4% and 6% respectively 0.9%. This means that any connection by adding EM4 concentration will increase the Phospor content (P_2O_5) in compost at both day 14 and 21. The concentration fulfills the requirement of SNI / 2004[6] namely Phospor quality standard (P_2O_5) minimum 0.10%.Element P in compost, is the main nutrient for plant growth. The content of P elements is higher with the occurrence of weathering of composted organic materials. At the maturation stage the microorganisms will die and the P content inside the microorganism will mix in the compost material which will directly increase the Phospor (P_2O_5) content in the compost[8].

3. Potassium (K_2O)

The result of laboratory examination of Potassium (K_2O) parameter that is on the 2nd week on the addition of EM4 2% is 2.8% and this is bigger than EM4 4% (2.31%) and 6% (2.4%). This is also true for 21 days of EM4 2% greater concentration of K than EM 4 4% and 6% concentration. Based on the requirement of SNI / 2004 that is at least 0.20%[6]. The EM4 addition in this study increase potassium levels beyond the above standards. This shows the activity of microorganisms using potassium (K) as a catalyst in the fermentation process.

4. Carbon Content (C)

The result of measurement of C level on 3 treatment of EM4 (2%, 4%, with 14 days and 21 days old) is 21.9-23.1% which has fulfilled SNI 19-7030-2004 that is 9.8-32%[6]. The difference of the C content is very small

and there is almost no difference between the amount of EM4 concentration and the length of the fermentation process.It can be selected by EM4 2% users with a shorter 14 day time. According to Ratriania et al. (2014) the addition of EM4 to the composting process will accelerate the composting process as the increase of microorganisms will increase the process of fermentation of the processed waste. In the composting, there is decomposition process that causes carbohydrate levels will be lost or continue to fall and the soluble N compound increases[12].

5. Level C / N ratio

Result of measurement in table 3, got the result of C / N ratio that is on week 2 and 3 is 13.2-15.5. While the requirement of SNI 19-7030-2004 about compost quality standard that is 10-20, good at treatment giving EM4 (2%, 4%, and 6%) for 14 and 21 days[6]. The C / N ratio is the ratio between carbohydrates (C) and nitrogen (N). If C / N ratio is larger than 20, it indicates incomplete C is oxidized to carbon dioxide (CO_2) and nitrogen is eliminated. The greater the EM4 concentration above will decrease the C / N ratio. This is reinforced by research results Yuniwati et al. (2012)[3]. The larger the EM4 concentration, the faster C / N ratio decreases, the shorter processing time will be, as the number of bacteria that breaks the material increases so that the material is decomposed more quickly by the bacteria. According to Fibria et al. (2012), the C / N ratio, element C is used as energy for the life of microorganisms and N elements for protein synthesis. If the C / N ratio is too high, the microbes will lack N for protein synthesis so that decomposition runs slowly. Composting of high C / N ratios, such as materials that contain high levels of wood (sawn timber, twigs, bagasse, etc.). The high decomposition process of C / N organic material will have a bad effect on the plant as it may cause the availability of other nutrients to decrease, as nitrogen is available in the soil[13].

CONCLUSION

Conclusion

1. Organic waste in the form of grass, leaves of sengon, mango, tiara and other shrub plants with waste capacity can be generated 5 to 20 kg / day.
2. Specification of mechanical box coper equipment capacity of 50 to 90 kg / hour, 1 unit digester, fermentation using EM4 2% within 21 days is an efficient result in the maturation of compost.

Suggestion

It is necessary to further investigate the increased capacity of mechanic box coper in order to obtain smooth mill results to accelerate the process of maturation of compost, cheap MOL materials, from local materials and the results Better than EM4.

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