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Decomposition Process of Disposable Baby Diapers in Organic Waste with Takakura Method

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ABSTRACT

Disposable baby diapers are usually considered as problematic non-biodegradable waste because it is made of sodium polyacrylate molecule. However, because of the high content of cellulose, disposable baby diapers waste can be recycled biologically. The objective of this study is to know the decomposition process of disposable baby diapers with organic waste into compost fertilizer according to the fertilization standard. This was an experimental study conducted by dividing 5 treatment groups, namely: P1 as control, P2 with the ratio of 20:80, P3 with the ratio of 40:60, P4 with the ratio of 60:40, and P5 with the ratio of 80:20. During the composting process the observations were conducted to the measurement variables of temperature, humidity, volume reduction and pH and final analysis of compost fertilizer. The study results showed that the highest mean of temperature was 53.3°C occurred at the beginning of the treatment and it was gradually decreased, then the mean of composting moisture persisted at 76% - 100% until the third week of the composting process and decreased to 4.43% in P1 and 25.71% in P5 in the last week of composting. The largest volume reduction occurred in P1 group that was equal to 10,5 liter, whereas the volume reduction in P5 group was 8,6 liter. The highest pH of 8 occurred in all treatments except P5 and there was only an effect of diapers on the composting humidity with p = 0,000. The quality of the compost produced has met the composting standard based on SNI No. 19-7030-2004 with the best ratio in P3 group, so it can be used for compost fertilizer material as a real alternative to 3R system.

Keywords: diapers, compost, Takakura

INTRODUCTION

Population growth and changes in community consumption patterns lead to increasingly diverse volumes, types and characteristics of waste. The further impact of increased human activity is increased amount of waste. If there is no human awareness to process it, then waste will become a serious problem. In order to avoid pollution or disaster, the waste, especially organic waste, can be managed at the source. [1]

Good and appropriate waste management may reduce environmental impacts and can overcome the problem of lack of artificial fertilizer needs. To deal with the waste problem, an easy, inexpensive and efficient technology needs to be applied, one of which is to use the technology of recycling waste into compost. [2] Composting does not only solve waste disposal problem, but can also recycle waste into useful products and even adds value since compost has high economic value because it can maintain and increase soil fertility. Without compost, the efficiency and effectiveness of nutrient absorption of plants from the soil will not run smoothly because it is strongly influenced by the content of organic matter in the soil. [3]

Along with the development of technology, the community lifestyle has changed such as the use of disposable diapers for toddlers that has replaced cloth diapers because it is considered more practical for toddlers and housewives regardless of the impact on the environment.

Many disposable diapers waste are sent to landfills and are dumped carelessly, because there is no alternative processing available because of the mixture of organic and inorganic composition in them. The increasing use of disposable diapers will cause new problem, namely environmental pollution. Nowadays disposable diapers are thrown away and not used. Even though in terms of technology and economy, disposable diapers can be managed and used. [4,5]

Disposable diapers are usually regarded as non-biodegradable waste which is problematic because they are made of sodium polyacrylate molecules. Sodium Polyacrylate is a polymer that is widely used in various products. The polymer compound has the ability to absorb as many as 200 - 300 times of its mass in water. [6]

However, because of its high cellulose content, disposable diapers waste can be recycled biologically to obtain the nutrients contained in it. [5]

Although disposable diapers contain poly acrylate compounds which are difficult to be decomposed, but when they are wet and filled with water, the polymer is easily broken so that they are easily decomposed. The presence of a water molecule inside disposable diaper makes the polymer compound is easier to cut into small pieces. [6] Therefore, a decomposing process can be carried out using the composting method. The composting was done in a way that has been commonly used by the community as a solid waste processing namely the composting method using the Takakura system. [4]

Takakura method has several advantages compared to other methods, which are practical because it is suitable for use on a small scale (household), does not require spacious area in its implementation, easy to conduct because the waste produced can be directly processed at any time without special treatment, and does not smell because the process is through a fermentation process, not decomposition. [2]

From the description above, it is necessary to conduct a study on the possibility of using diapers as compost and to obtain the ideal conditions for the continuity of the composting process to produce the compost in accordance with the compost standard for fertilization.

MATERIALS AND METHODS

Experiment on the decomposition of disposable diapers with comparison group was carried out in the Workshop on the Department of Environmental Health of the Health Polytechnic of Ministry of Health of Aceh in May to September 2017. The subjects used were disposable baby diapers that have been used to retain babies' and children' urine without feces, taken in an absorbent section located between two sheets of non-woven fabric as much as 24 liters or 0.024 M3 for 4 treatment groups which were be mixed with fermentation seed and organic waste.

Diapers were obtained from 5 toddlers who had previously been given new diapers with the same brand. The study procedure began with making a starter of microorganisms or decomposers made in 2 types of solutions, namely starter with sugar solution and starter with salt solution, then making Seed Fermentation from two ingredients, namely rice husk and bran with a ratio of one to one mixed with both starter solutions which had been previously made to reach moisture of 40-60% and the results were left for 5-7 days.

Composting process was done by inserting Takakura compost seeds into each basket until 60% of basket volume, organic waste and disposable diapers with a ratios of diapers and organic waste of P1 = 0:100, P2 = 20:80, P3 = 40:60, P4 = 60:40, P5 = 80:20. After stirring, a black cloth was placed over each basket then the baskets were covered tightly and stored in the shade, by avoiding direct sunlight for 90 days, measurements were taken every day to note temperature, moisture, volume reduction, color and pH. When the compost finished, two thirds of it was taken then was moved

into a sack and was left for 2 weeks for normalization process. Then the compost was taken to be tested for macro nutrients and bacteriological content in the laboratory including the ratio of C/N, N, P, K, Zn, organic matter and analysis of Fecal coli bacteria.

RESULTS

1. Composting Temperature

A drastic increase in composting temperature occurred on the second and third days of composting which reached 61ºC from the initial temperature of 32ºC, then the temperature gradually decreased until the 20thday of composting until it reached a stable temperature (32ºC - 27ºC) on the 90thday of composting process as shown in figure 1:

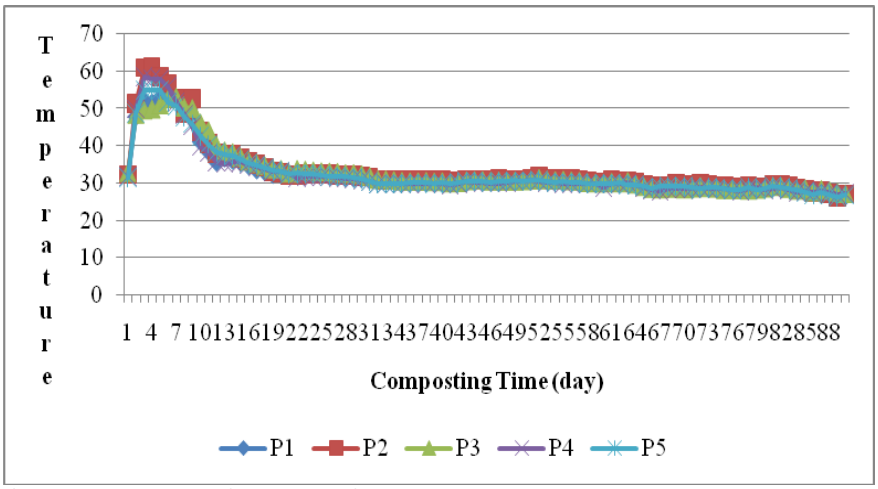

Figure 1. Graph of temperature changes for 90 days of disposable diapers composting process in organic waste using Takakura method

There was no significant difference (p=0.934) between each treatment of disposable diapers composting on the organic waste composting temperature using Takakura method.

2. Composting Moisture

The increase in moisture to 100% on the first day to the third day of composting occurred in treatments I, II, III and IV while treatment V showed 100% moisture since the first day of treatment. Then treatment I showed a decrease in moisture faster than the other treatments which began on the 10thday of 100% moisture until it reached the lowest moisture of 3% on the 90thday of treatment, while treatment V showed a decrease from 100% on the 40thday of treatment until it reached the lowest moisture of 25% on the 90thday of treatment (figure 2)

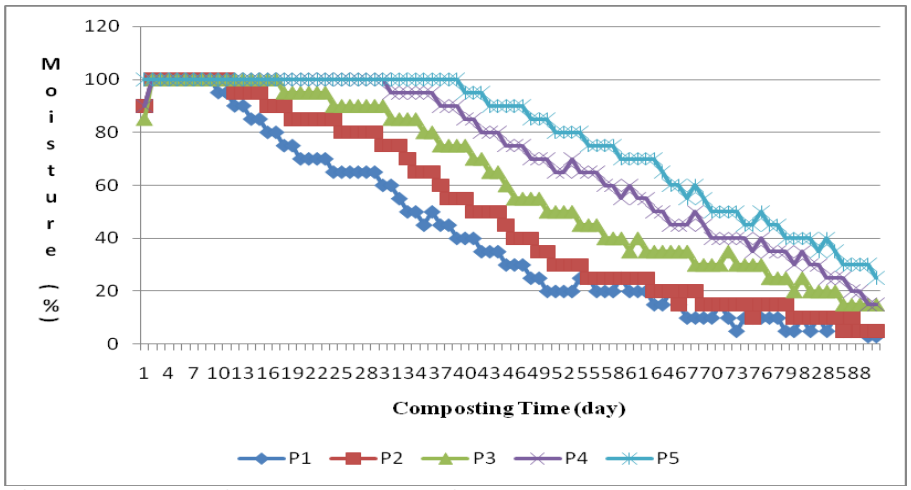

Figure 2. Graph of changes in moisture for 90 days the process of disposable diapers composting (organic diapers) using Takakura method.

There was a significant difference (p=0,000) in the five treatments for disposable diapers composting on the moisture of organic waste composting using Takakura method. There were significant differences between P1 group with P3, P4 and P5 groups, then P2 group with P3, P4 and P5 groups then P3 group with P4 and P5 groups (p<0.05), except between groups P1 with P2 and groups P4 with P5 (p>0.05).

3. Composting Volume Reduction

The composting volume reductionwas stable in all treatments. The largest number of volume reduction occurred in weeks I, II and III of composting with the average difference per week of 2.38 liters. In treatment I the amount of volume reduction from week I to week XIII of composting was 10.5 liters, while in treatment V the amount of volume reduction from week I of composting to week XIII of composting was 8.6 liters (figure 3).

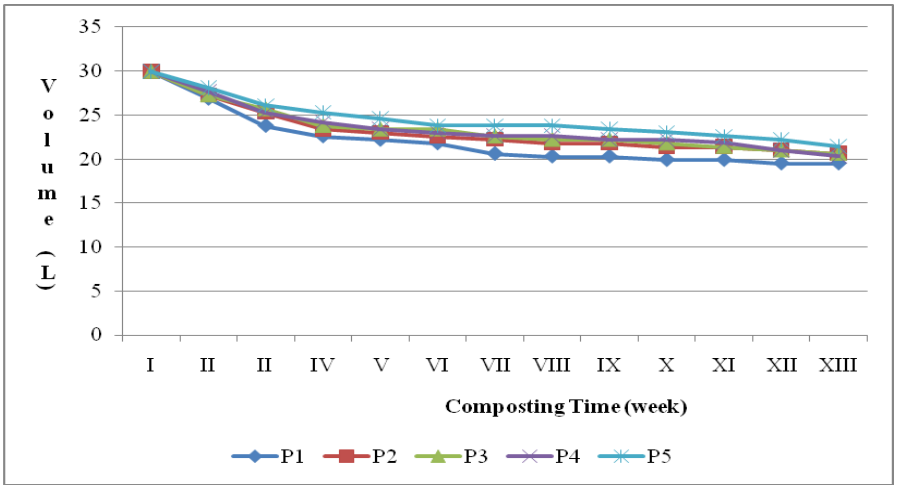

Figure 3. Graph of volume changes during the process of disposable diapers composting in organic waste using Takakura method.

There was no significant difference (p=0.306) between each treatment of disposable diapers composting on the change in composting volume of organic waste using Takakura method.

4. Composting pH

All treatments showed a decrease in pH from the start of composting until they rose again in the middle of the week of composting, then the pH returned to a normal pH of 7 from the week XI of composting to the week XIII of composting. The highest pH of 8 occurred in all treatments except treatment 5 in week I to week VIII (figure 4).

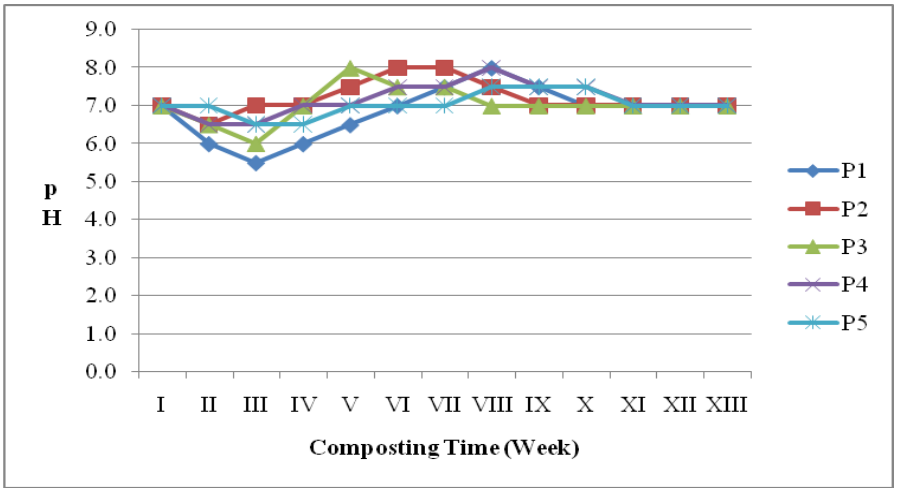

Figure 4. Graph of changes in pH during the process of disposable diapers composting in organic waste using Takakura method.

There was no significant difference (p=0.412) between each treatment of disposable diapers composting on the organic waste composting pH using Takakura method.

5. Quality of Compost

The quality of compost produced met the composting standards based on SNI No. 19-7030-2004 except for color parameter and different amounts of Fecal coli, while groundwater temperatures ranged from 27 - 31 °C in the treatment location (table 1).

Table 1. Quality of the Final Result of the Process of Composting Disposable Diapers in Organic Waste Using Takakura Method Based on Composting SNI No. 19-7030-2004

No	Parameter	P1	P2	P3	P4	P5	SNI
1	Water content (%)	11,70	14,74	22,31	19,14	17,70	<50
2	Temperature (ºC)	29,50	29,50	30,00	30,00	29,50	Groundwater temperature
3	Color	Brown	Brown	Brown	Brown	Brown	Blackish
5	pH	7,34	7,49	7,49	7,39	7,30	6,80 - 7,49
6	Organic Ingredients (%)	51,65	53,30	47,50	45,59	40,10	27 - 58
7	Nitrogen (%)	2,03	2,17	2,09	2,14	2,08	>0,40
8	Phospor P2O5 (%)	8,75	8,35	7,81	8,94	8,44	>0,1
9	C/N Ratio	14,79	14,28	13,22	12,39	13,45	10 - 20
10	Potassium K2O2 (%)	0,79	0,76	1,03	0,59	0,51	>0,2
11	Zinc (mg/Kg)	25,63	33,69	13,2	13,44	40,13	<500
12	Fecal coli (MPN/gr)	>2400	>2400	460	>2400	1100	<1000

DISCUSSION

1. Composting Temperature

In treatment 1 without the addition of disposable diapers experienced the slowest temperature increase compared to other treatments, this also occurred in the treatment with the addition of leachate and MOL, wherein without treatment the thermophilic phase took longer than the variation with the addition of leachate and MOL. [8] Temperature is one indicator in breaking down organic matter. The achievement of the thermophilic phase (40-65 ºC) is due to the height of the compost pile. The appropriate height of compost pile is 1-1.2 meters and the maximum height is 1.5-1.8 meters. Furthermore, after passing through the thermophilic phase, the compost pile has a decreased temperature again at the mesophilic temperature. [9]

In all treatments the highest temperature did not exceed 61ºC because bacteria become inactive for more than 2 hours at temperature above 60ºC and aerobic bacteria become slow during the composting process. [10]

Degradation of organic waste and disposable diapers showed the initial thermophilic phase, where the temperature reached up to 60ºC. This is necessary because increasing temperatures can eliminate pathogenic bacteria in disposable diapers. [11]

Aerobic composting will lead to a temperature increase quite quickly during the first 3-5 days and the temperature of the compost can reach 55-70ºC, at this temperature the microorganisms can be tripled compared to temperatures less than 55ºC. The enzyme produced also the most effective in decomposing organic matter at this temperature. [12]

The compost temperature in each treatment relatively showed a similar tendency, after which it showed a downward tendency to reach the temperature of 30ºC on the 13th day. The temperature of the treatment was relatively stable after the 13th day in the range of 29-31ºC. [13]

2. Composting Moisture

There was a significant difference (p=0,000) among the five treatments for disposable diapers composting on the moisture of organic waste composting using Takakura method, this occurred due to the Sodium Polyacrylate contained in disposable diapers which has the ability to absorb as much as 200-300 times of the mass in water. [6] Thus, the more composition of disposable diapers used in the treatment of organic waste composting, the higher the moisture content that occurs.

During the composting process there was no addition of water to all treatments, only based on the initial moisture so that the moisture dropped gradually and surely, the greatest decrease in moisture occurred in treatment I without disposable diapers. This is not in line the study conducted by Recep Külcü in Turkey who used livestock manure and greenhouse waste as compost material, wherein the compost moisture in each treatment decreased faster. So, to keep the composting process running optimally the treatment with a moisture value below 55% was watered, and the moisture level was set above 60%. During the process, it was observed that changes in moisture levels did not differ significantly from each other. [14]
Optimal moisture ranges from 40-60%, more than that or too wet can inhibit the composting process, and will cause an unpleasant odor. [15] However, along with the duration and high temperature of the outside air during the composting process, the optimum moisture cannot be maintained. Considering that the composting material used had high moisture and room air temperature during the composting process was around 30ºC, so Takakura method was chosen for the composting process of disposable diapers because this method is very suitable for use in tropical regions of Indonesia with temperatures of 27ºC - 35ºC and on average it reaches 31ºC [16] so that the water content contained in disposable diapers can be reduced to the maximum.

3. Composting Volume Reduction

Volume reduction occurred due to the process of decomposition by microorganisms involved in the composting process. Microorganisms came from starters made from yeast and sugar which were then mixed with fermentation seed. Yeast microorganisms include saprophytes, living on organic matter from dead plants or animals. The substance in which it grows is called an organic substrate. Yeast contains protease, amylase and lipase enzymes and has the effect of breaking down proteins, carbohydrates and fats. [13]
The composting process of Takakura basket style is an aeraob composting process in which air is needed and oxygen is an important intake in the growth process of microorganisms that break down waste into compost. The media needed in the composting process is by using a hollow basket, filled with materials that can provide comfort for microorganisms. [17] The high reduction of volume in the first week was due to the presence of mesophilic microorganisms that function to reduce the particle size of organic matter. Another cause was the relatively large availability of organic materials that are easily decomposed by microorganisms that allow the proliferation of microorganisms that decompose the organic material. [18] The low volume reduction in treatment 5 was due to by the large proportion of disposable diapers containing high cellulose of 35% and Sodium Polyacrylate or Superabsorbent polymer (SAP) of 33% in compost [19] so that the material was slowly decomposed by microorganisms.

4. Composting pH

pH or acidity degree of the material at the beginning of composting was generally acidic to neutral. The degree of acidity at the beginning of the composting process decreased due to the number of microorganisms involved in composting process that converted organic matter into organic acid. In the next process, other types of microorganisms converted organic acids that had been formed so that the material had a high degree of acidity and closed to neutral. Too high degree of acidity will cause the nitrogen element in the compost to turn into ammonia (NH3), whereas in an acidic state it will cause some microorganisms to die [12]
At the initial stage, the composting pH is in acidic condition. At this stage there is a process of forming organic acids, locally causing pH to be in acidic condition. Acidic conditions will cause fungal growth and will decompose lignin and cellulose in compost material. Furthermore, the pH gradually increases. This occurs because of the

ammonia formation process during the composting process of compounds that have nitrogen content. In addition, if anaerobic condition develops during the composting process, organic acids will accumulate. Adding air or periodic turning process has a role in reducing the acidity of the compost. [20] However, differences in pH values obtained from compost of disposable diapers did not have an impact on plant growth. [11]

5. Quality of Compost

All composts produced had the quality that met the composting standards based on SNI No. 19-7030-2004 except for the parameters of color and different amounts of Fecal coli. This difference was due to the use of fermentation seed from the ingredients of bran and rice husk, so the compost produced was brown. This difference can be attributed to the heterogeneity of the initial organic matter and several possible small differences due to treatment in the composting process such as the turning or stirring the compost and normalization process of compost. [15]

CONCLUSION

Fertilizer from the decomposition process of disposable diapers processed with the Takakura method were stable and had a good quality based on SNI. [20] The compost had a higher water content which was 22.31% for P3, high organic matter content up to 53.30% for P2 and total nitrogen content that reached 2.17% for P2 and C/N ratio was in the range of 10-20. Treatment 3 with the ratio of 60:40 was the best wayto mix organic waste and disposablediapers for the composting process using the Takakura method, so that it will produce the final outcome of the composting process withhigh-quality compost that will be useful in agriculture.

It should be noted that the mixing ratio of organic waste with disposable baby hdiapers to be used due to the study results showed that the quality of compost produced did not show a direct proportionality with the number of disposable diapers added.

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