Effect of pH, temperature and moisture content during composting of rice straw burning at different temperature with food waste and effective microorganisms

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Abstract. Rice straw is considered as one of the most important agricultural residues and represented as one of the major by-products from rice production process. Normally, rice straw that produced after harvesting season been directly burned on-farm. Conversion of rice straw into value added compost will improve the productivity of plant, reduction of pollution towards environment and reduction of local pollution due to open burning activity. The objective of this study was to evaluate the performance of composting rice straw ash (RSA) with food waste (FW) and effective microorganisms (EM) in term of the compost quality (pH, temperature, moisture content). RSA was prepared by burning the raw rice straw at three different temperature of 300°C, 400°C and 500°C for one hour. EM used during the composting process was prepared by mixing of brown sugar, 'tempe' and water that can be used after one week of fermentation process. There are four treatments of RSA-compost; RSA (300°C), RSA (400°C), RSA (500°C) and control (raw rice straw) with the same amount of compost medium; 1kg black soil, 0.5kg RSA, 3L EM and 1kg FW. The composting process happens for 30 days. During the composting process, all the parameters of RSA-compost obtained in a range like; pH value 8-10, temperature 20-50°C and moisture content 40-60%. The result showed that all compost quality of rice straw ash compost obtained in an acceptable range for final compost to establish.

1 Introduction

One of the main agricultural productions in Asia is rice. Hence the production of rice straw in Asia is higher. Statistic shows that, each kilogram of grains harvested, rice straw generated are between 1.0-1.5 kg [1]. Normally rice straw produced after harvesting season been directly burned. Conversion of rice straw into value added compost will improve the productivity of plant, reduction of pollution towards environment and reduction of local pollution due to open burning activity [2].

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On the other hand, in 2011 at least 1184371.6 tonnes of rice straw has been produced in Northern Region of Malaysia [3]. Usually, farmers will manage the residue by on site burning or use it as household domestic use such as for cooking. In Malaysia, straw burning method was use due to crop rotation that needs to be done. Decomposing of rice straw naturally cannot be done due to limitation of time. Rice straw burning will cause haze. Based on a study that has been done in a journal, they stated that by burning a tones of rice straw, 3 kg of particulate matter, 1460 kg of carbon dioxide, 60 kg of carbon monoxide, 2 kg of sulphur dioxide and 199 kg of dust will be produced [4].

According to National Solid Waste Management Department also stated that between 31% until 45% of 36000 tonnes of garbage is food waste. Most of the food waste that been produced will be sent to landfill while the incineration and food waste treatment will consume large cost. Malaysian also did not realize that roting food waste is one of the main factors of greenhouse gas due to production of methane gas [5]. Existing of methane gas will increase 23 times of global warming compare to carbon dioxide. Based on a research that has been done by Environment Protection Agency (EPA)'s statistics, it show that less than 3% of food waste been recycle or recovered in 2010 showing that 97% of the food waste will be dumped into landfill area. In the same article written in The Star Online, based on statement from Waste and Resource Action Programme (WRAP) in 2015, about 7% of greenhouse gas emission that equal to 3.3 billion tones in a year has been produced through food waste wasted. They added that 1 billion tones per year of greenhouse gas can be reducing by reducing the food waste amount [5]. One of the way to reduce the amount of food waste end up to landfill, we can reuse or recycle them as composting material.

From the issue that has been stated, rice straw and food waste can be combining together to be used as composting material for organic fertilizer production. The content of fertilizer that will be produced in this research must at least as same as commercial's fertilizer content. So that the global warming issue due to rice straw's open burning especially by farmers will be reduce through composting of food waste and rice straw ash. At the same time, utilization of landfill towards food waste disposal will be minimized. In this research, rice straw ash was produced by using different burning temperature in order to determine the quality of compost possessed by each temperature during composting process.

2 Materials and methods

2.1 Raw Sample Preparation

Rice straw been collected from Wang Ulu's paddy field in Perlis for about 10 kg. Then the collected rice straw allowed drying under open air for a week. After a week, the dried rice straw was grinded using Plastic Shredder Machine into small pieces which were between 1-5mm. Rice straw was burning at different temperature of 300°C, 400°C and 500°C using CF1100 muffle furnace. The amount of rice straw ash that should be produced at each temperature was 0.5 kg.

Then the process continue by production of 12 litre fermented liquid using 1 kg of brown sugar, 4 pieces of *tempe* and 12L of water. The mixture was left for a week in the dark place to allow the fermentation process to occur.

Food waste was collected from Dragon's food stall. Food waste had been rinse using tap water before blended. The amount of food waste use for each compost medium including control was 1kg.

2.2 Preparation of Compost Containers

The type of containers use in this project were baskets that contain holes along it side to allow aeration process occurred. The dimension of compost container was shown in Fig. 1. The diameter of the container was 31 cm while height of container was 30 cm.

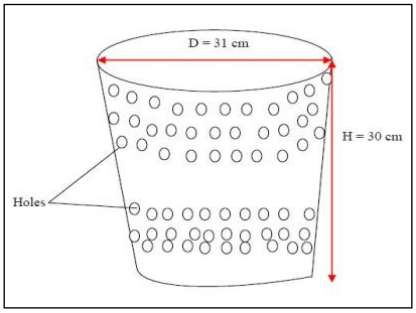

Fig. 1. Dimension of basket use as compost container.

2.3 Preparation of Compost Medium

The compost medium was prepared by mixing 1kg of black soil, 0.5 kg of rice straw ash, 3L of fermented liquid and 1 kg of food waste. The process was repeated for each temperature of rice straw ash. While for the control, raw rice straw without burning was used. The illustration on composition of compost medium prepared was showed in Fig. 2 and Fig. 3.

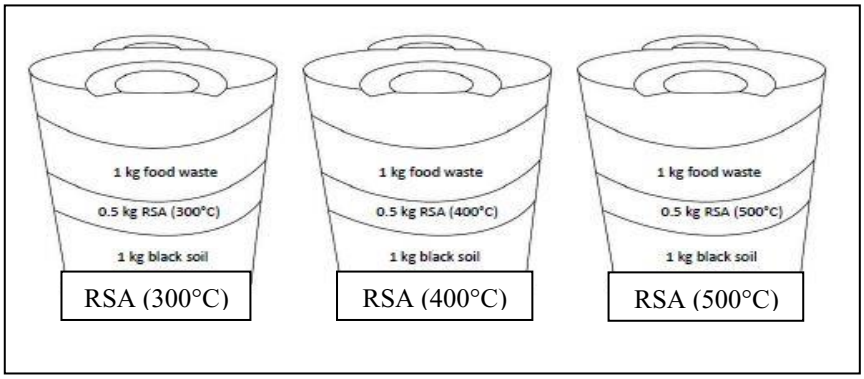

Fig. 2. Cross-section of compost medium using different temperature of rice straw ash.

2.4 Parameters Analysis

Parameter that been analyse during compost period were pH, temperature and moisture content. Temperature been analyse by using mercury thermometer by placed at certain point for 60 seconds. There were 3 different point should be test for temperature [6]. pH that measure by dissolving 1g of compost sample into 10 ml of distilled water. The ratio of sample dissolved should be in 1/10 [7]. Then the pH was taken using pH meter after 1 hour. Moisture content of sample was determined by usng ASTM 02974 oven-dry method where 20 g of sample been placed into oven for 24 hours at temperature of 105°C [8].

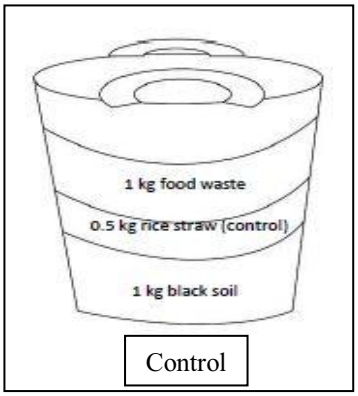

Fig. 3. Cross-section of compost medium using rice straw as control.

3 Results and discussions

3.1 Effect of pH during the composting process

Based on a study conducted, the pH value during compost process was varied within the pH of 4.9-8.3. While the optimum pH should exist between range of 7-8 when a test on pH dependency of microbial activities using liquid medium of proteins and glucose was conducted [9].

Based on the Fig. 4, the pH value is increasing from day 1 until day 12. The increase in pH value indicates that the decomposition of organic matter inside compost medium was occurred and ammonium was formed [10]. pH pattern for RSA(300°C) was slightly different from control and RSA (400°C) and RSA(500°C) where the value begin to decrease until reaching slightly neutral condition as reaching day 21 with 7.9 value. As for control, the pH become neutral on day 18 with value 7.6 which was 3 days earlier compared to RSA (300°C). Besides, the pattern of pH for RSA (300°C) show the longer decline period compared to other medium where the pH value start to decline from day 15 until day 21 while other medium pH decrease up until day 18. Decrease in pH value might caused by formation of carbon dioxide gas and organic acid during organic matter decomposition [10, 11].

After day 21, the pH value in RSA(300°C), start to change from neutral to alkaline condition on day 24 where the value was 8.6 and start to decline back on day 27 until day 30 from 8.3 to 8.1. Changes on pH value from 7.9 to 8.6 for RSA(300°C) and 7.6 to 8.1 for rice straw(control) may affected by the frequency of turning during composting period [12].

As for RSA (400°C) and RSA (500°C), the pH increase from day 18 until day 30. As for RSA (400°C) the pH increase from 8.4 on day 18 until reach value of 9.6 on last day of composting period. While for RSA (500°C), the pH increase from 8.2 on day 18 to 9.8 as it reaching day 30. The changes may cause by released of protein that comes from the mixture of vegetables remains that use along composting process [12]. Hence, from the result obtained based on pH value, the best quality of compost was RSA at 300°C since the pH value were almost similar with the optimum pH compared to other.

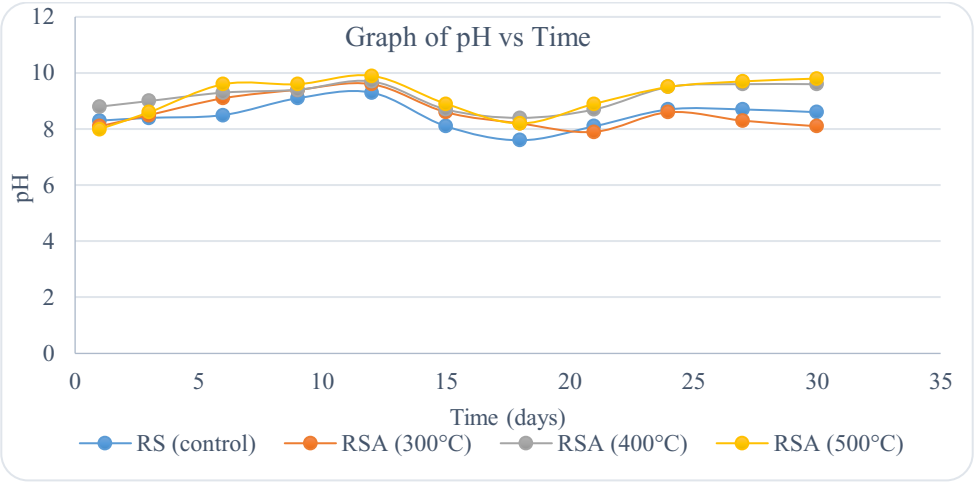

Fig. 4. Graph of pH of compost medium.

3.2 Effect of temperature during composting process

Based on the graph in Fig. 5, the highest temperature in control medium is at 50°C that recorded on day 6 before it falling to temperature 44°C on day 9. As for rice straw ash (RSA), the compost medium that has the highest temperature is RSA (500°C) which possessed the same temperature value as control on day 6 which was 50°C before decrease to 42°C on day 9. Increase in temperature was lead to the existing of thermophilic stage that mainly influence by the level of microbial activity that cause significant changes in psychochemical properties of composted material which also allow the decomposition of hemicelluloses, cellulose and lignin. By comparing the result of RSA(300°C) and RSA (400°C) with RSA(500°C), the microbial activity inside the RSA(300°C) and RSA (400°C) is lower compared to RSA (500°C). Besides, the changes in compost temperature was also influences by mixing frequency that can affect the oxygen supply towards compost medium [2].

After that the temperature of compost continues to decrease. From the result obtained, on day 24 the temperature of compost including control was 26°C and continue to decline until reaching day 30 with 22°C. The decrease in temperature indicates that the microbial activities started to slow down due to the low amount of organic material available. Hence the microbial activity stopped and reached the cooling stages [12].

Rice straw that been burned at temperature 500°C was seen as optimum temperature for rice straw ash composting since it achieved the highest value of temperature which was 50°C compared to other temperature of rice straw burning.

3.3 Effect of moisture content on composting process

The moisture content value obtained in this study showed in Fig. 6. The range of moisture content in this study was within 40 % to 59 %. Based on a journal, the range of an ideal moisture content that must be possessed by compost medium was within 40-60% [13]. While in other study, it stated that the optimum moisture content to ensure the condition in an active phase is within range of 45% to 50% [14].

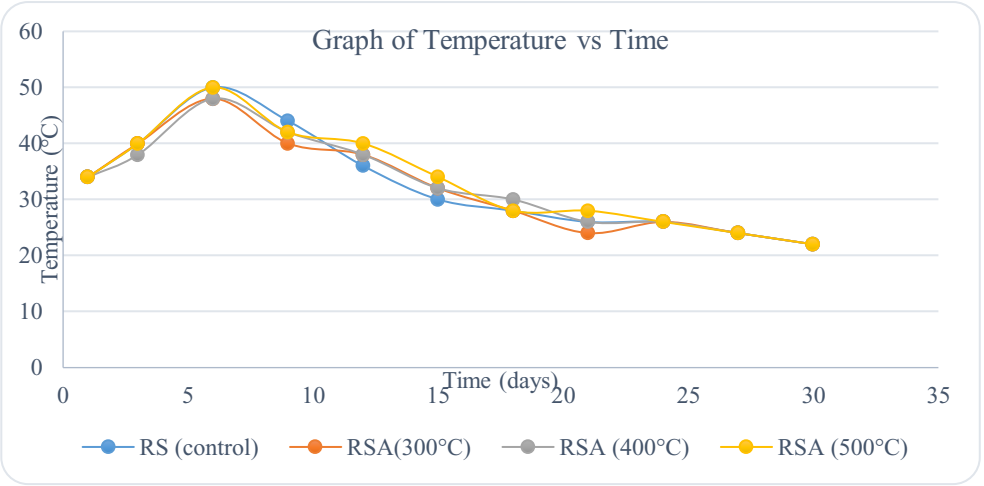

Fig. 5. Graph of temperature compost medium.

Roughly, based on the graph in Fig. 6, the amount of moisture content in each of the compost medium was showing a fluctuation. As for control, the highest moisture content is on day 21 while the lowest moisture content is on day 12 which were 59 % and 40 % respectively. As for RSA (300°C), RSA (400°C) and RSA (500°C), the highest moisture content was on day 1 which were 58% respectively. While the lowest moisture content for RSA (300°C) was 40 % on day 6. Lastly the lowest moisture content for RSA (400°C) and RSA (500°C) similar which were 45 % on day 30.

Moisture content affect by temperature distribution of compost medium. The main factor of moisture content loss is due to the rising in compost temperature [12]. However in this study, the temperature of compost did not give obvious effect towards moisture value since the amount of food waste inserted much higher than the rice straw ash and rice straw (control) as bulking agent along the compost period. High moisture content inside food waste cannot been absorbed by bulking agent efficiently causing the moisture content become unsteady [15].

The most good quality sample for this parameter was RSA(400°C) and RSA(500°C) since the range minimum moisture content laid within the optimum moisture content range which is 45% compared to RSA(300°C).

4 Conclusions

Composting using rice straw ash and food waste achieved the maturity of compost in 30 days. The pH possessed by control were within 7.6 to 9.3 compared to RSA (300°C), RSA (400°C) and RSA (500°C) which were between 7.9 to 9.6, 8.4 to 9.6 and 8.0 to 9.8 respectively. The range of temperature obtained from this study, control sample and RSA (500°C) temperature value were within the range of 22°C to 50°C. While for RSA (300°C), RSA (400°C) range of temperature were between 22°C to 48°C. Then from data analysis on moisture content, control value varied between 49% to 59% while for RSA (300°C), the moisture lied within 40% to 54%. As for RSA (400°C) and RSA (500°C), the value was in the range of 45% to 57% and 45% to 56% respectively.

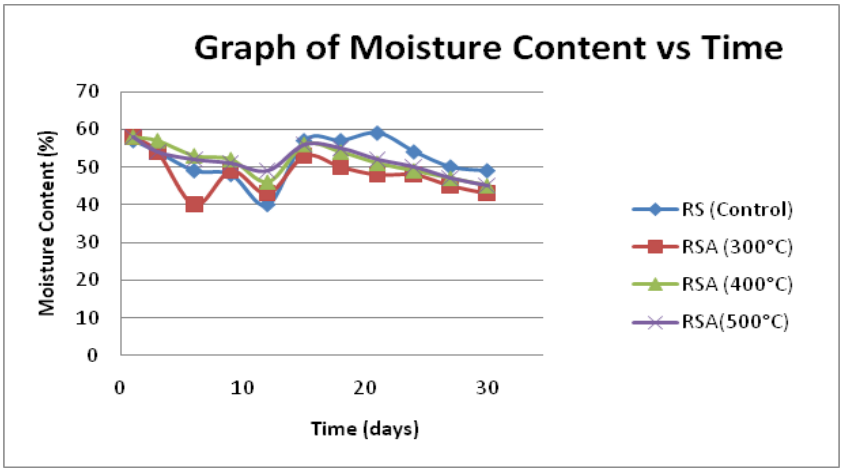

Fig. 6. Graph of moisture content of compost medium.

In this research, the classification of best composted was determine based on temperature. Hence based on result obtained by this research, among RSA (300°C), RSA (400°C) and RSA (500°C) the best compost medium was RSA (500°C) which it temperature at thermophilic phase was the highest which was 50°C. During composting process, the fermented liquid that made from *tempe* and brown sugar was used. Usage of fermented liquid considered as good since it was able to stimulate the soil microbial growth and activity. Besides, usage of brown sugar can be served as food towards the microbes either from *tempe* or compost medium itself. Optimum moisture content must be maintained to avoid foul odour production.

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