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Rice Husk and Microorganisms Addition Increased Domestic Solid Waste Composting Process

Ellina S. Pandebesie*, Dety Rayuanti

Department of Environmental Engineering, Institut Teknologi sepuluh Nopember, Indonesia

ABSTRACT

The objective of this study was to determine the effect of rice husk and microorganism addition on solid waste degradation rate. In this study, some efforts were made to increase compost process by adding rice husk and microorganisms into the domestic solid waste. The addition of rice husk aimed to obtain C/N ratio due to the composting criteria and reducing the moisture content in the compost material. The addition of microorganisms aimed to shorten acclimatization time and increased pH of compost material. The experiment was carried out by mix of raw material, rice husk and microorganisms. Five reactors were carried out on aerobic condition and solid waste pile was turned once a day. Rice husk and microorganism was added to reactor as followed, R1: without rice husk and microorganism; R_2: 4 kg and 1 ml/kg; R_3: 8 kg and 1 ml; R_4: 4 kg and 2 ml/kg and R_5: 8 kg and 2 ml/kg raw material. The composting period was 30 days in batch process.The results showed the best waste solid waste degradation rate occurred in reactor R_3, which composting rate increased by 11.7% when it compared to the control reactor.

Key words: composting, degradation, microorganism, rice husk, solid waste

INTRODUCTION

Municipal solid waste composting methods has been applied in Indonesia for a long time. In terms of its inexpensive costs and rather simply technique, composting was used widely, especially in developing countries. Conventional composting was carried out by dumped garbage in holes in the ground. Then once full garbage covered by soil, the garbage was degraded after a few months, usually about two months. The finished compost will be able to use to improve and treat the soil [1]. In densely populated urban areas, the conventional composting methods are difficult to implement, because composting process produced odor and leachate. Leachate potentially contaminates groundwater and surface water. This is because of organic and inorganic substances of leachate. The composting process aimed to accelerate the process of compost maturation, and the process did not pollute the environment [2]. Composting process can be applied aerobic or anaerobic processes [1]. In general, the advantage of anaerobic process produced biogas which can be used as energy. But, if the biogas produced just flare into the air, it will create the greenhouse gases effects. In addition, this process also caused odor. The Advantage of aerobic process is not produce odor; thus, it is more suitable for individual household.

Production of rice husk, a by-product and agrowaste that causes environmental problems, increased every year, therefore some efforts should be made to utilize it. Rice husk was evaluated as a possible additive to composting to ascertain its contribution to the biological efficiency and nutrient content [3]. The water absorption capacity of the composting mixture by rice husk was the dominant physical property that affected the composting rate. It also increased free air space of the composting pile, which aerobic process would accelerate composting rate and higher temperature reached due to more [4]. It was showed that rice husk is a good material to be mixed with raw compost material with high water content.

Organic waste through a degradation process was transformed by microorganism activity, until the organic waste was stable, that was odorless and turned a black or dark brown color [1]. Composting rate is low in early stages due to limited microorganism availability. Microorganisms addition was produced more stable compost than without microorganism addition [5]. Microorganism addition increased the molecular weight and humus acid of compost product, and it also improved the efficiency of the composting process [6]. Adjusting pH and microorganism addition also accelerated the composting process [7]. Composting process performed on rotating reactor was showed the higher temperature composting process, the higher solid waste degradation rate [8]. Garbage turning affected temperature, pH, total carbon, total nitrogen, and C/N ratio. Carbon and nitrogen reduction of the garbage was increased by increase turning frequency [9].

Mixing of raw material, rice husk and microorganisms was made to obtain optimum water content and C/N ratio for composting process. It was expected to increase the composting rate. This could be enhanced by turning solid waste and force air to reactor naturally. The objective of the study is to determine the effect the rice husk and micro-organisms addition on solid waste composting rate.

***Corresponding Author:** Ellina S. Pandebesie. Institut Teknologi Sepuluh Nopember, Email: ellina@its.ac.id

MATERIALS AND METHODS

Compost Materials

Compost materials derived from market solid waste, dominated by vegetables and fruits. Market garbage consists of organic material mostly, which is decomposed easily with moisture content about 80%. The addition of rice husk aimed to reduce solid waste moisture content. Optimum moisture content of composting process ranged from 50 to 60% It is also aimed to improve the ratio of C/N in order to obtain optimum ratio ranges from 20/1 to 25/1 [10]. The optimum C/N ratio was to accelerate degradation rate. It involved the energy in the heat generated form by the oxidation of organic carbon to carbon dioxide, as well as the organic matter decomposed to small size [1]. Microorganism addition aimed to increase composting rates. A composting process by seeding with an inoculums containing was found viable to improve the composting efficiency [11]. This research used Biostarter M-16, which produced from cow rumen. Biostarter M-16 extracted from cow rumen contained various kinds of microorganisms whose role was needed in the process of organic matters decomposition. Biostarter was taken from Airlangga University.

Solid waste characteristics are shown in Table 1. Variations of research carried out by rice husk and M-16 addition. A total of five composting reactor was used in the experimental setup. Rice husk and market solid waste mixed by different input materials. Rice husk and market solid mixed to achieve a total weight of 20 kg. Experimental variations design of rice husk and M-16 addition are shown in Table 2.

Tabel 1: Characteristics of raw wastes and rice husk

Parameters	Market Solid Waste	Rice Husk
Moisture (%)	83	14.2
pH	4.15	-
C (%) based on dry weight	52.28	38.68
Nitrogen	2.64	0.41
C/N ratio	19.8	94
P	0.45	1.5
K	0.3	1.54

Tabel 2: Research Variables

Mikroorganism	1 ml/kg raw compost	2 ml/kg raw compost
Rice Husk: 4 kg	R2	R4
Rice Husk: 8 kg	R3	R5
Control	R1 (without rice husk and M-16 addition)	

Equipment and parameters measured

A laboratory scale reactor was used in this experiment. Reactor is a rotated cylindrical drum, perforated to allow air entered naturally. The reactor was rotated once a day, so the air could get into the trash pile. Solid waste turning was improved solid waste degradation [11]. This is because it could flatten temperature and microorganism in the garbage pile, so that microorganisms degraded waste faster. Reactor equipped by leachate discharge pipe. The composting period was 30 days in batch process. Measurements of temperature, pH and moisture content were done every day. The samples were collected and analyzed content of C and N performed once in three days. The initial and final compost were taken for pH, temperature, moisture content, carbon, nitrogen, phosphorus, and potassium analysis. Moisture content and organic volatile compound were measured by gravimetric method. Estimated C content calculated by %Volatile/1.8 [12]. Total Nitrogen measured by Kjeldahl Method. Phosphorus measured by spectrophotometer and potassium measured by Flame photometer.

RESULTS AND DISCUSSION

Effects of rice husk and microorganisms addition on solid waste degradation rate

Effects on Operation Conditions

Composting processes influenced by temperature, moisture content pH and C/N ratio. These factors are expected to strongly affect microbial activities and diversity in the compost [2]. In this experiment, temperature increased about a week in each reactor. Temperature increased from about 30°C to about 45°C for reactor R_2, R_3, R_4 and R_5, while at control reactor (R_1) the highest temperature achieved at 35°C. Temperature decreased gradually to 30°C at the end of experiment. Temperature increases in the composting process showed microorganism activity increase [8]. Increasing temperature started since the beginning of experiment. It showed the addition of microorganisms increased the activity of micro-organisms from the beginning of the

experiment. Microorganism activity will increase by increased temperature, so composting rate will increase Temperature of reactor R_2, R_3, R_4 and R_5 reached higher than the temperature of control reactor. This suggests that the addition of rice husk and microorganisms would increase composting rate.

In the beginning of experiment moisture content was still high about 75% to 83%. The highest moisture content was 83% in control reactor. Microorganisms required water for their activities. When moisture content was high enough, free air space inside a pile of garbage was reduced. Formed ammonium dissolved into water and utilized by micro-organisms as a source of nutrients. This was reduced NH_3 emissions into the air [13, 2, 14]. But, very low or very high moisture content inhibited microorganism activities due to dehydration or anaerobiosis (tiquia). Final moisture content ranged from 50% to 60%. The lowest final water content achieved by R_3 and the highest water content was in the control reactor.

The pH decrease in the beginning of composting on control reactor may occur due to the formation of volatile acids. It was 4.85 on the first day and increased gradually to 8.14 by the end of composting. Low pH restricted microorganism activity. The pH of other reactors was range 7.2 to 7.8 in the beginning, due to microorganism addition. Microorganism addition accelerated the activity of microorganisms, which increased pH of composting process [14]. During the composting process the pH increased from about 7 to 8.2.

C/N ratio during composting was highly fluctuating. It could be due to the ammonification and nitrification. The high temperature in the beginning of composting caused NH_3 emissions [13. During the composting material degradation by micro-organisms, ion N was released. In the aerobic composting process, if the content of N available in the compost is high enough, then the nitrification process occurred that caused the content of N released to the atmosphere as N_2O. But in this experiment moisture content was high, so NH_3 dissolved to water, therefore C/N ratio was fluctuated.

Effects on composting rate

The living environment of microorganisms is also incessantly changing with the increase of metabolite production and biochemical reaction. In the beginning of composting, the organic matter concentration is high enough while the microbial community is limited. Thus, seeding with various inocula, i.e., increasing the microbial concentration, was helpful to composting at this stage [1]. Solid waste degradation rate was determined by using decreased C content data under operational conditions. C concentration reduced on R_1, R_2, R_3, R_4 and R_5 were 7.1%, 7.5%, 12.3%, 6.1% and 5.1% respectively. It was almost the same if it was compared to other research, which obtained 12% [13]. The highest C concentration reduced obtained from R_3. From Fig.1, it was obtained that degradation of C content as a function of time followed first order reaction expressed as $\ln C/C_0 = -kt$. where *C* is the quantity of C content at any time, t is the time in days, *k* is the reaction rate constant (day^{-1}). Linearized equation obtained from Fig.1 can be seen in Tabel 3. The highest composting rate obtained from R_3, indicated by k value. This could be due to high initial moisture content on the four other reactors compared to R_3, thus microorganism activity was inhibited. Rice husk and microorganism addition increased solid waste degradation rate about 11.7% compared to without rice husk and microorganism addition.

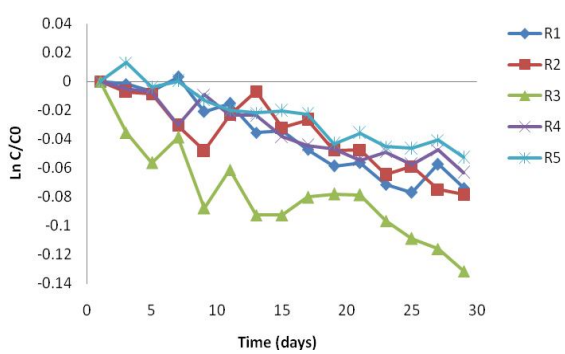

Figure 1: Effect of rice husk and microorganis addition on composting rate

Table 3: Composting rate as k

Reactors	Equations	k	R^2
R1	Y1 = -0.003x – 0.032	0.003	0.852
R2	Y2 = -0.002x + 0.000	0.002	0.780
R3	Y3 = -0.0034x-0.0263	0.0034	0.784
R4	Y4 = -0.002x – 0.000	0.002	0.885
R5	Y5 = -0.002x – 0.008	0.002	0.910

Effect of rice husk and microorganism addition on final compost quality

The final product of this research is compost. Determination of the quality of the final compost product observed from measurements of the content of C, N, P, K, C / N ratio, temperature and its moisture content can be seen in Table 4. In the end of composting process moisture content reached 50% in reactor R3. It showed on day 30, the moisture content met Indonesia National Standard (SNI) for the compost. Moisture content was reduced by 30% in the end of composting. In this study, the low moisture content reduction also caused by leachete retained in the bottom of reactor. In the future reactor design must consider slope of reactor, so leachate can flow out well. Ph value of 7.7 is slightly above the maximum SNI in which pH was 7.49. C/N ratio of 22.93 is slightly above where the SNI, which C/N ratio of compost ranged from 10 to 20. The final temperature is 30°C throughout all reactors in the end of composting. Some of the parameters mentioned above indicated that composting is still necessary to continue the process of maturation. But in general, the final compost product is good, compared to SNI for compost.

The content of nitrogen in compost is one of the indicators to obtain the final compost product quality. Most of the nitrogen content in compost organic nitrogen, usually in the form of protein. A small portion of organic nitrogen mineralized into ammonia form, due to the activity of micro-organisms on the ammonification. Ammonium formed can be dissolved and used again by microorganisms as a source of energy and reformed organic nitrogen. Ammonia formed can be released into the air, if the pH is above 7.5 [16]. pH value maintained 7 to 7.5 in order to obtain an optimum composting process, because ammonia volatile gas was not creation and released into the air on pH under 8.5 [10]. Microorganism contains 14% nitrogen, 3% and 1% potassium phosphate (Metcalf & Eddy, 1993).

In this study, the pH during the composting process ranged from 7.5 to 8.5, so most of the ammonium released into the water. The results of measurements of the total N content in the final product shows N content increased, the mean ammonium should be released into the air retained in the compost. In reactor R_2, R_3 and R_5 nitrogen content increased by 70%, 54% dan70% respectively. It can be caused due to waste water content dropped sharply at the end of composting, so the waste measured drier. In drier conditions, ammonium will evaporate, so the total nitrogen was measured in samples smaller than the initial nitrogen content. The content of N was fluctuated from the start of composting, and sometimes it showed a lower value than initial value, but then increased again. R4 reactor conditions same to the control reaction, although the total nitrogen content of the control reactor was also increased by 20%. R4 waste degradation rate was smaller when compared to other reactors. The rate of degradation of waste showed activity microorganisms were less active than other reactors. Lack of inactivity microorganisms could cause poor dissolved ammonia that can be utilized by microorganism, resulting in the production of organic nitrogen was reduced. Consequently, measurement of total nitrogen also reduced. In this study, compost material consists of vegetables, which contains high lignin. Raw material composts with high lignin content can reduce the loss of nitrogen [16] and high C content can also decreases loss of nitrogen [17]. It was proved rice husk and microorganism addition improved the quality of compost.

The content of phosphate and potassium decreased from the initial conditions. This is because the microorganisms utilize phosphate as a nutrient for growth. The content of the final phosphate on R1, R2, R3 and R4 more than 1%, where the figure met the SNI, and the content of phosphate in the R5 was not meet the standard. Potassium content in the end of composting on R_1, R_2, R_3 and $_{R5}$ were less than 2% as required by SNI.

Tabel 4: Final compost quality

Parameters	R1		R2		R3		R4		R5	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Moisture (%)	82.76	60.12	76.37	58.91	75.07	50.47	80.19	52.73	81.32	59.14
pH	4.85	8.14	7.72	8.13	7.51	7.70	7.84	8.10	7.57	8.07
C (%)	53.30	46.84	45.28	41.87	48.27	42.32	45.32	42.54	45.35	43.02
Nitrogen	1.84	2.21	1.59	2.71	1.20	1.85	2.27	1.64	0.92	1.57
C/N ratio	28.97	21.19	28.48	15.45	40.23	22.88	19.96	25.94	49.29	27.40
P	1.82	1.15	1.54	1.20	1.94	1.10	1.38	0.26	0.09	0.04
K	0.43	1.19	0.97	0.23	1.58	0.25	0.91	0.19	2.24	0.23

CONCLUSION

The solid waste degradation rate affected by rice husk and microorganism addition, which the best result showed by R_3 in which contained 8kg rice husk + 1 ml M-16 in 1kg compost. Solid waste degradation rate increased about 11.7% compared to without rice husk and microorganism addition. Rice husk and microorganisms addition also affected compost quality, where the quality of compost met Indonesian national standard.

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