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Recycling Organic Waste in Suan Sunandha Rajabhat University as Compost

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***Abstract*—**This research aimed to study on the potential of recycling organic waste in Suan Sunandha Rajabhat University as compost. In doing so, the composition of solid waste generated in the campus was investigated while physical and chemical properties of organic waste were analyzed in order to evaluate the portion of waste suitable for recycling as compost. As a result of the study, it was found that (1) the amount of organic waste was averaged at 299.8 kg/day in which mixed food wastes had the highest amount of 191.9 kg/day followed by mixed leave & yard wastes and mixed fruit & vegetable wastes at the amount of 66.3 and 41.6 kg/day respectively; (2) physical and chemical properties of organic waste in terms of moisture content was between 69.54 to 78.15%, major elements for plant as N, P and K were 0.14 to 0.17%, 0.46 to 0.52% and 0.16 to 0.18% respectively, and carbon/nitrogen ratio (C/N) was about 15:1 to 17.5:1; (3) recycling organic waste as compost was designed by aerobic decomposition using mixed food wastes : mixed leave & yard wastes : mixed fruit & vegetable wastes at the portion of 3:2:1 by weight in accordance with the potential of their amounts and their physical and chemical properties.

***Keywords*—**Compost, Organic waste, Physical and chemical properties, Recycling.

I. Introduction

SUAN Sunandha Rajabhat University is located in Dusit district, Bangkok, Thailand on the area of approximately 10 hectares. In 2011, the total number of under graduated and graduated students together with all academic staffs and employees was about 20,000 people while the amount of solid waste generated in the campus was anticipated at 1.2 to 1.5 tons/day during the week day and 1.0 ton/day during the week end. Because of this, recycling solid waste in the campus especially organic waste by any approaches i.e., composting or producing refuse derived fuels (RDF) as alternative energy should be considered. However, the aim of this research is to focus on the recycle of such organic waste which includes mixed food wastes, mixed leave & yard wastes, mixed fruit & vegetable wastes for composting. It is hoped that the production of compost by organic waste can be useful to the campus not only by minimizing the budget to dispose of solid waste but also by helping the campus save the budget to purchase chemical fertilizers for maintaining the outlook of landscape in the campus.

Municipal solid waste or MSW can be categorized by composition into 4 groups which includes organic waste, recycle waste, non-recycle waste and household hazardous waste [1]. Of these, organic waste plays more important role than others in terms of its percentage for all composition. In Thailand, it was reported that composition of MSW across the country were 63.57% by organic waste, 16.83% by plastics, 8.19% by papers, and 3.47% by glasses as shown in Fig. 1 [2]. Not only in Thailand but also in many countries such as Poland and China have higher percentage of organic waste in their solid waste streams than others (Table I) [3]. By this reason, recycling organic waste as compost becomes a popular waste management option since communities find ways to divert portions of their waste from landfills. It is apparent that landfill is currently run out of space because sites for new disposal facilities become increasingly difficult to find, more restrictions are put into place by regulating agencies, and also public opposition to such facilities grows everywhere. Thus, recycling program of organic waste as compost or any other approaches must be implemented.

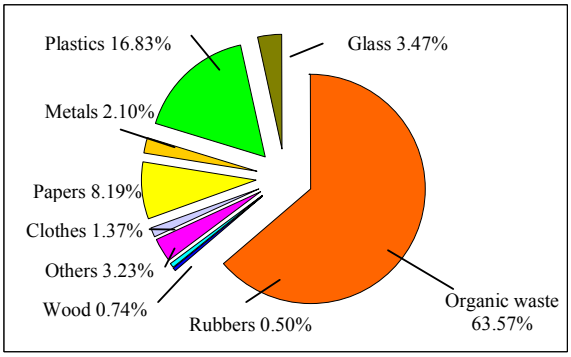

Fig. 1 Composition of MSW in Thailand

TABLE I
Typical Composition of MSW in Poland and China

Component	Poland (%)	China (%)
Food wastes	24	36
Paper, cardboard	11	2
Plastics	2	1.5
Glass	6	1
Metals	2	1
Clothing/Textiles	10	1.5
Ashes, dust	45	57
Unclassified (e.g., garden, yard, wood)	-	-

Utilization of organic waste by composting can be applied to transform food wastes, yard and garden waste particularly leaves and grass clippings, or any other organic matters (OM). In fact, composting is the biochemical degradation of organic waste. The end product of composting is called "humus-like material" that can be used primarily as soil conditioner.

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Composting processes are normally designed for aerobic decomposition. In an aerobic process, microorganisms living in an oxygen environment decompose the organic waste as the following equation [3]:

$$OM + O_2 \longrightarrow new\ cells + CO_2 + H_2O + NH_3 + SO_4 \quad (1)$$

The process of composting depends on several parameters of relevance. These include moisture content, temperature, oxygen, carbon/nitrogen ratio (C/N), pH and particle size of waste [3].

A. Moisture Content

The optimum moisture content for composting is between 50 to 60%. At less than 50% moisture content, the metabolic activity of microorganisms slows. At greater than 60%, on the other hands, the moisture inhibits oxygen access by filling the voids between particles and causes a temperature reduction.

B. Temperature

Composting is an exothermic activity that temperature can change throughout the decomposition process. Best result of composting can be achieved if temperature reaches 122 to 140 °F or 15-40 °C (thermophilic stage) within a few weeks and maintains until the end of the process. Temperatures greater than the thermophilic range inhibit biological activity of microorganisms.

C. Oxygen

Oxygen is essential for aerobic decomposition during the composting process. With a low oxygen level, it is found that the decomposition process becomes anaerobic condition which turns to a much slower process and also generates odors. Thus, turning and ventilating the compost can keep the oxygen at a sufficient level.

D. Carbon/nitrogen Ratio (C/N)

This ratio is an optimum of biochemical conditions which occur in the range of 20:1 to 40:1. If the ratio is less than 20:1, carbon-rich material is needed. On the other hands, if the ratio is greater than 40:1, nitrogen-rich compound should be added to the composting process.

E. pH

The optimum pH range for composting organic waste is from 6 to 8. At the beginning period of decomposition process, however, the pH is as low as 5 since organic acids are formed. Then, the pH rises as these acids are decomposed especially during the thermophilic stage.

II. Objectives of the Study

Three objectives of the study on recycling organic waste in Suan Sunandha Rajabhat Universtity as compost were as follows:-

- To investigate the composition of solid waste generated in the campus,
- To analyze physical and chemical properties of organic waste related to recycling as compost, and
- To evaluate the portion of different types of organic waste suitable for recycling as compost.

III. Methodology

A. Investigation of Solid Waste Composition

Composition of solid waste in the campus was investigated in terms of the amount of waste generated per day. To do so, solid waste discarded in garbage bins surrounding the campus was collected and separated by its composition into organic waste (i.e., mixed food wastes, mixed leave & yard wastes and mixed fruit & vegetable wastes) and non-classified waste (i.e., foams, plastic bags, water bottles, cans, and tissue papers). Each composition of solid waste was measured by weight as kilogram per day once a week in a weekday for 4 months from August to November 2010. Then, the total amount of both organic and unclassified wastes generated per day was recorded.

B. Analysis of Physical and Chemical Properties of Organic Waste

Organic waste generated in the campus which includes mixed food wastes, mixed leave & yard wastes and mixed fruit & vegetable wastes were sampled in order to analyze for their physical and chemical properties. In this study, the sampling of organic waste was designed by 3 times per month during July to November 2010 with the total number of 15 samples for each type of organic waste. These samples were analyzed for the following properties which are relevant to the process of composting (1) moisture content, (2) major elements for plant as nitrogen (N), phosphorus (P), and potassium (K), and (3) carbon/nitrogen ratio (C/N). Then, one-way ANOVA was used to compare the difference of each property among three types of organic waste at the significant level of .05.

C. Evaluation of the Portion of Organic Waste Suitable for Recycling as Compost

This part focused on evaluating an optimum portion of organic waste in decomposition process so that the end product of composting can meet the standard enacted by Land Development Department, Ministry of Agriculture and cooperatives of Thailand. Aerobic condition was employed in the decomposition process in order to transform mixed food wastes, mixed leave & yard wastes and mixed fruit & vegetable wastes as compost or humus-like material for plant. Designing the optimum portion of each type of organic waste in this study was based on two main factors as follows; (1) the chemical property of waste particularly carbon/nitrogen ratio which should be equal or close to 20:1 to 40:1, and (2) the amount of each type of organic waste generated per day; the greater amount of waste, the higher portion to be used in the composting process.

IV. Results and Discussions

The results of this research can be reported into 3 parts in accordance with objectives of the study.

A. Investigation of Solid Waste Composition

Solid waste composition in Suan Sunandha Rajabhat University by this research was classified into organic waste and non-classified waste. It was found that the total amount of organic waste was averaged at 299.8 kg/day or 0.3 ton/day while the total amount of non-classified waste was averaged at 1,279.5 kg/day or 1.28 tons/day (Table II). These data show that the average amount of organic waste generated per day in the campus was about 19% which is enough to use as raw material for composting program. Table II also indicates that mixed food wastes had the highest amount of 191.9 kg/day followed by mixed leave & yard wastes and mixed fruit & vegetable wastes at the amount of 66.3 and 41.6 kg/day.

TABLE II
THE AMOUNT OF ORGANIC WASTE GENERATED PER DAY IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Unit: kg/day

Sampling date	Mixed food wastes	Mixed leave & yard wastes	Mixed fruit & vegetable wastes	Non-classified waste
11/08/2010	312	40	35	1,723.5
18/08/2010	130	42	20	1,397.0
25/08/2010	350	37	52	1,538.0
01/09/2010	108	56	31	1,548.0
08/09/2010	190	65	45	1,604.0
15/09/2010	126	100	33	1,685.0
22/09/2010	140	112	40	1,386.0
29/09/2010	175	150	42.5	1,111.0
06/10/2010	200	50	20	809.0
13/10/2010	314	103	60	886.0
20/10/2010	112	50	40	830.0
27/10/2010	185	48	51	839.0
03/11/2010	128	39	44.5	1,374.0
10/11/2010	274	71	69	1,246.0
17/11/2010	135	32	41	1,241.0
24/11/2010	-	-	-	1,257.0
Average	191.9	66.3	41.6	1,297.5

B. Analysis of Physical and Chemical Properties of Organic Waste

The result of analyzing physical and chemical properties of organic waste is shown in Table III, and can be described in the following details;

- Moisture content was found in the range of 69.54 to 78.15% which mixed fruit & vegetable wastes had the highest level followed by mixed food wastes and mixed leave & yard wastes, respectively. It is considered that such level of moisture content might not be optimized for composting process because it is greater than 60%. However, this problem can be solved by reducing moisture content of organic waste especially mixed fruit & vegetable wastes and mixed food wastes before using them as raw materials for composting program.
- N, P and K which are important for plant growth were found in the range of 0.14 to 0.17%, 0.46 to 0.52%, and 0.16 to 0.18%, respectively. Table III shows that mixed fruit & vegetable wastes had the highest levels of these three major elements when compared to the others.
- Carbon/nitrogen ratio (C/N) found in mixed food wastes, mixed leave & yard wastes, and mixed fruit & vegetable wastes were 17.5:1, 17.2:1 and 14.8:1, respectively. These ratios are less than an optimum range for composting. Therefore, any other organic material is needed to mix with the organic waste in order to increase such ratio up to 20:1to 40:1 so that the recycle of organic waste as compost can be done more successfully.

TABLE III
PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC WASTE IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Property of waste	Mixed food wastes	Mixed leave & yard wastes	Mixed fruit & vegetable wastes
Moisture content (%)	75.23	69.54	78.15
Nitrogen (%)	0.14	0.15	0.17
Phosphorus (%)	0.48	0.46	0.52
Potassium (%)	0.16	0.17	0.18
Carbon/nitrogen ratio (C/N)	17.5:1	17.2:1	14.8:1

Statistical comparison of each property of the waste was also done by means of one-way ANOVA. Data shown in Table IV indicate that there were no difference of each property among mixed food wastes, mixed leave & yard wastes, and mixed fruit & vegetable wastes except for the moisture content [sig. = .003 < α (.05)].

TABLE IV
STATISTICAL COMPARISON BY ONE-WAY ANOVA OF PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC WASTE

Property of waste	Organic waste	Mean ($\overline{X}$)	F	Sig.
Moisture content (%)	1	78.1538	6.267	.003
	2	75.2308		
	3	69.5385		
Nitrogen (%)	1	0.1738	1.519	.226
	2	0.1423		
	3	0.1462		
Phosphorus (%)	1	0.5169	0.383	.683
	2	0.4754		
	3	0.4631		
Potassium (%)	1	0.1775	2.096	.130
	2	0.1627		
	3	0.1712		
Carbon/nitrogen ratio (C/N)	1	14.7608	0.400	.672
	2	17.4558		
	3	17.2258		

Remark: 1 represents mixed fruit & vegetable wastes. 2 represents mixed food wastes. 3 represents mixed leave & yard wastes

C. Evaluation of the Portion of Organic Waste Suitable for Recycling as Compost

The portion of organic waste that is suitable for recycling as compost was evaluated by using two factors which consisted of the amount of each type of organic waste generated per day and carbon/nitrogen ratio (C/N) of the waste. Followings were the data of these two factors reported in part A and B;

- The amount of mixed food wastes generated per day was averaged at 191.9 kg/day and its carbon/nitrogen ratio (C/N) was as low as 17.5:1.
- The amount of mixed leave & yard wastes generated per day was averaged at 66.3 kg/day and its carbon/nitrogen ratio (C/N) was as low as 17.2:1.
- The amount of mixed fruit & vegetable wastes generated per day was averaged at 41.6 kg/day and its carbon/nitrogen ratio (C/N) was as low as 14.8:1.

Based on these data, it was therefore designed to use mixed food wastes, mixed leave & yard wastes, and mixed fruit & vegetable wastes at the portion of 3:2:1 by weight for composting. By this portion of organic waste, decomposition process of composting occurred as shown in Fig. 2.

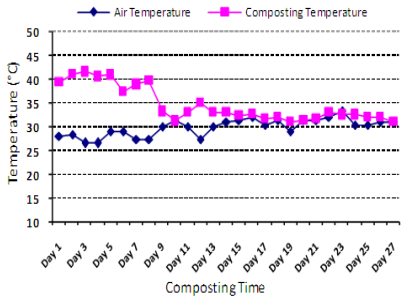

Fig. 2 Composting process was completed in 27 days or about 4 weeks

According to Fig. 2, composting process was completed in 27 days or about 4 weeks. Temperatures throughout the process varied from 42 °C at the initial stage to 31 °C at the final stage in which composting temperature was the same level as air temperature. The end product of composting or humus-like material derived from this study was analyze for its property again in order to compare with the standard enacted by Land Development Department, Ministry of Agriculture and cooperatives, as shown in Table V.

TABLE V
THE PROPERTY OF COMPOST DERIVED FROM RECYCLING ORGANIC WASTE IN SUAN SUNANDHA RAJABHAT UNIVERSITY

No.	Property (Unit)	Sample of compost	Composting standard *
1	Moisture content (% w/w)	11.03	> 35
2	Nitrogen (%)	3.52	≥ 1.0
3	Phosphorus (%)	0.90	≥ 1.0
4	Potassium (%)	1.71	≥ 0.5
5	Carbon/nitrogen ratio	12:1	20:1
6	pH	6.33	6.0-7.5
7	Organic matter (% w/w)	72.57	25-50

* Land Development Department, Ministry of Agriculture and Cooperatives, Thailand [4].

Table V shows that some properties of compost derived from this study i.e., nitrogen (N), phosphorus (p), potassium (K) and pH were along with the composting standard. On the other hands, the remaining i.e., carbon/nitrogen ratio (C/N), moisture content and organic matter were apparently out of such standard. For example, C/N and moisture content were much less than those enacted by the standard. It is, therefore, recommended to improve some techniques during the process of decomposition so that the end product derived as compost will be as good as the standard.

V. CONCLUSION

Recycling organic waste as compost is one of the interesting programs that should be encouraged by authorized people in any organization. Important sources of organic waste such as schools, colleges and universities are those where the waste recycling program must be initiated. The aim of this research is to find out how to recycle organic waste i.e., mixed food wastes, mixed leave & yard wastes, and mixed fruit & vegetable wastes generated in the university as compost more effectively and practically. Expected results from this research are mainly to save budgets not only for the dispose of a large amount of organic waste, but also for the purchase of chemical fertilizers in the garden work. Moreover, the implementation of this recycling program can return the atmosphere of clean environment to the university as a whole.

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