Phosphorus Recovery from Co-composting of Faecal Sludge and Fresh Food Market Waste

Weerapong Hanrinth and Chongchin Polprasert

Abstract— *Fresh food market waste (FFMW), faecal sludge (FS), garden waste, and human urine are the potential sources for nutrients recycling due to its exponentially increasing amounts and containment of a varieties of plant minerals. The aim of this paper is to investigate the process of co-composting the above mentioned wastes, using the conventional in-vessel composter. Enhancing nutrient contents; for example nitrogen, phosphorus, and potassium; has been found to achieve in this study. Applying human urine in both FFMW and FS co-composting processes has increased the level of phosphorus to about 31.30 and 2.52%, respectively. The final products are suitable for use in plant growing, according to their physical and chemical properties.*

Keywords— **About four key words or phrases in alphabetical order, separated by commas.**

1. INTRODUCTION

Nowadays one of the major environmental impacts comes from solid wastes generated from people living in the urban areas. Their amounts have been continually increased in municipal areas, due to the rapid population growth, the socio-economic expansion as well as the technological advances. According to the PCD final report (2004), the composition of municipal solid wastes around Thailand were investigated and evaluated in 2003 to find that food/organic wastes approximately generated in each regions of the country were 60% of total solid waste. While those generated from market in Bangkok contained food/organic waste of 69.26 % [1].

Organic wastes generated around the country was about 63.57 %. If degradable wastes and recyclable wastes are broadly utilized, the outcome obtained not only affects the environmental preservation and human health risk protection but also saves a lot of costs in solid waste management.

Co-composting both fresh-food market wastes and faecal sludge is a good approach to utilize the wastes since organic waste and faecal sludge are useful raw materials [2, 3], which contain the abundant essential nutrients for plant cultivation [4, 5]. The final product may be enriched sufficiently for use as organic fertilizers. At present, the government has attempted to implement organic farming so as to decrease the import of chemical fertilizer. Therefore, it is a good alternative way to recycle the nutrients for food cultivation as well as protect the environment. The type of solid waste suitable for composting is decomposable wastes or garbage, while human excreta which is one type of organic waste contains valuable substance for plants such as carbon(C), nitrogen(N), Phosphorus(P), and other trace elements [6].

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Furthermore, [7] demonstrated that the generation rate of the elements in the excreta was 7.6-7.9 g N/cap/day, 1.6-1.7 g P/cap/day and 1.8-17 g K/cap/day, representing high macronutrients to be used as fertilizer.

Although nutrient recycling from faecal sludge and fresh food market wastes has tremendous benefits for environmental protection and economics of the country, studies about co-composting of organic waste and faecal sludge have not been found in Thailand. Therefore, this research aims to investigate the process of co-composting, using the conventional in-vessel composter. The final products produced are expected to have the properties equivalent to those of the national fertilizer standard or higher [8].

2. METHODOLOGY

In this study, the experiments were conducted at the Service and Environmental Quality Development Centre (SED) of Nonthaburi Metropolitan Municipality. Four kinds of raw materials were selected as co-composting sources. Firstly, faecal sludge (FS) was taken from the anaerobic digestion plant in Nonthaburi municipality.

Secondly, fresh food market waste (FFMW) comprised vegetable residue, fruit peel, and food debris derived from Thanam Nont fresh-food market. The third major material was garden wastes (GW) collected from public park, including wood chips, leaves, and grass residues. They were used as a bulking agent. Finally, human urine collected from household unit was used for the purposes of nutrient adding and moisture content adjustment.

The co-composting equipment is set-up by applying the in-vessel composting method from the Department of Pollution Control (PCD)**.** Prior to composting of each experimental run, the mixture of raw materials was prepared to have the proper compositions suitable for the biological reactions to proceed; i.e., C/N ratio between 20 – 25 and moisture content of about 40%. Composting pile were separated into four reactors, each reactor was triplicated in order to gain the average value of each physical and chemical parameters. Household bin was applied as the studied reactor with L-shape drilled pipe located at the center of the reactor for the purpose of air flow within the reactor **(Fig.1)**.

Composting process are divided into three main stage; preparation, composting, and post-experiment with the composting period approximately six month. The experiments were designed and classified into four sets varied by the mixture of co-composting material as shown in **Table 1**

Before the composting processes are performed, four types of raw materials are grabbed in order to analyze the preliminary physical and chemical properties, including moisture, organic matter (OM), organic carbon (OC), C/N ratio, nitrogen, phosphorus (P_2O_5), potassium (K_2O), pH, electrical conductivity (EC), calcium (CaO), magnesium (MgO), sulfur (S), and GI. A sample of each set was taken to be a representative final product.

After the composting processes completed, a sample of final product was sent to the laboratory of the Office of Science for Land Development, Department of Land Development, the Ministry of Agriculture and Cooperatives in order to examine the post physical and chemical properties and compare with the Thai Agricultural Commodity and Food Standard (TACFS 9503-2005: Compost).

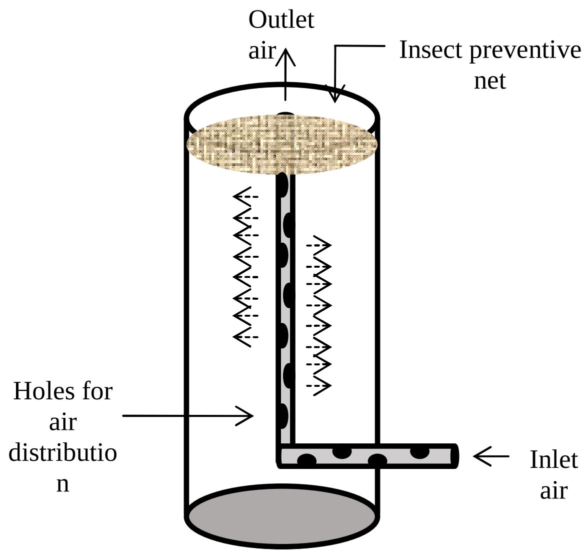

Fig. 1 Experimental reactor for composting

3. RESULTS AND DISCUSSION

In this study, collected raw materials including fresh food market waste, faecal sludge from anaerobic treatment process, garden waste, and human urine were sent to analyze the preliminary physical and chemical properties before the composting process was performed.

Table 1 Experimental designed for composting materials

Treatment	Co-composting raw materials			Moisture control mixture	
	GW	FFMW	FS	With urine	Without urine
1	✓	✓			✓
2	✓	✓		✓	
3	✓		✓		✓
4	✓		✓	✓	

Results show the moisture content of tested raw materials (FFMW, FS, and GW) were found to be 89.36, 16.77, and 6.45%, respectively. While the TACFS has suggested the optimal moisture should not more than 35%, therefore, FFMW has moisture content higher than the standard.

For organic carbon (OC), organic matter (OM), and C/N ratio were also investigated, the results found that the contents of organic carbon (OC) of previous three materials were found to be 37.57, 24.87, and 51.31%w/w, respectively. At the same time, the organic matter (OM) were found to be 64.77, 42.88, and 88.46 %w/w, respectively. These obtained results are totally higher than the TACFS, which suggests that the OM level should be no more than 35%. For C/N ratios, of FFMW, FS, and GW were found to be 8.31, 9.87, and 58.98, respectively. Therefore, GW is added as to adjust within the mixture.

C/N ratio of the compost mixture to be about 20-25 and to serve as supporting material to create void volume

In addition, the experiment results gained from this pre-test demonstrated that nitrogen, phosphorus, and potassium of four materials (FFMW, FS, GW, and urine) were found to be 4.52, 2.52, 0.87, and 0.88 %N, 0.88, 2.74, 0.19, and 0.10 %P_2O_5 and 3.11, 0.24, 0.36, and 0.14 %K_2O, respectively. Compared to the recommended standard for compost, the results indicated that only FFMW has the most suitable properties as to be a compost material, while three of all including FS, GW, and urine contained the macronutrients still less than this standard.

In the first experimental runs, two of four raw materials were selected as a representative of co-composting materials; FFMW and GW, moisture content was controlled by addition of water. The results found in this experiment showed the moisture decreased from 76.86% to 35.32% which slightly exceeded the recommended value (no more than 35%).

Similarly, the OC, OM, and C/N ratio of these mixture material have reduced to 41.58%, 71.69%, and 15.25. In contrast, the percentage of macronutrients (N,P, and K) increased from 2.11, 0.58, and 2.26% to be 2.73, 1.15, and 2.91%, respectively, which are higher than those of the TACFS.

In the second experimental runs, three of four raw materials were selected as a representative of co-composting materials; FFMW, GW, and urine. The results found in this experiment showed the moisture decreased from 73.64 to 35.63% which slightly exceeded the recommended value (no more than 35%).

The OC, OM, and C/N ratio of these mixture material have reduced into 41.45%, 71.46%, and 15.53, which were acceptable with the compost standard. On the other hand, the level of macronutrients (N,P, and K) increased from 2.39, 1.10, and 1.80% to be 2.67, 1.51, and 3.39%, respectively, which are higher than the National Thai standard for compost.

In the third experimental batch, FFMW was substituted by faecal sludge plus garden waste, moisture content was controlled by adding with water as same as those first in the experiments 1. After six months of composting, the final product was taken to the laboratory center for analyses of physical and chemical parameters. The results show moisture decreased from 49.74% to 26.87%. The OC, OM, and C/N ratio of these mixture material have also reduced to 36.76%, 63.37%, and 12.19, respectively. While the content of three major nutrients have risen from 2.74, 2.28, and 0.45 to 3.02, 2.78, and 0.65 % for N, P_2O_5, and K_2O, respectively.

Lastly, in experimental run 4, FS and GW were fermented, moisture content was maintained by adding with urine as same as that in the experimental run 2. The mixture material was collected and analyzed before the fermentation process was implemented. After six months, the final product was grabbed to examine the properties. Results shows moisture dropped from 53.81% to 29.68%.

The OC, OM, and C/N ratio of these mixture material have also declined into 34.15%, 58.87%, and 10.81, respectively. Similarly, the macronutrients (nitrogen, phosphorus, and potassium) have increased from 2.75, 2.16, and 0.55 to 3.16, 2.85, and 0.61 % for N, P_2O_5, and K_2O, respectively. Furthermore, additional parameters such as EC, pH, CaO, MgO, S, and GI are illustrated in **Fig. 2**

Another results from composting fresh food market waste and faecal sludge show the different percentage of nutrient contents between the FFMW composter (Experiment run 1 and 2) and FS composter (Experimental run 3 and 4), which are shown in **Table 2.**

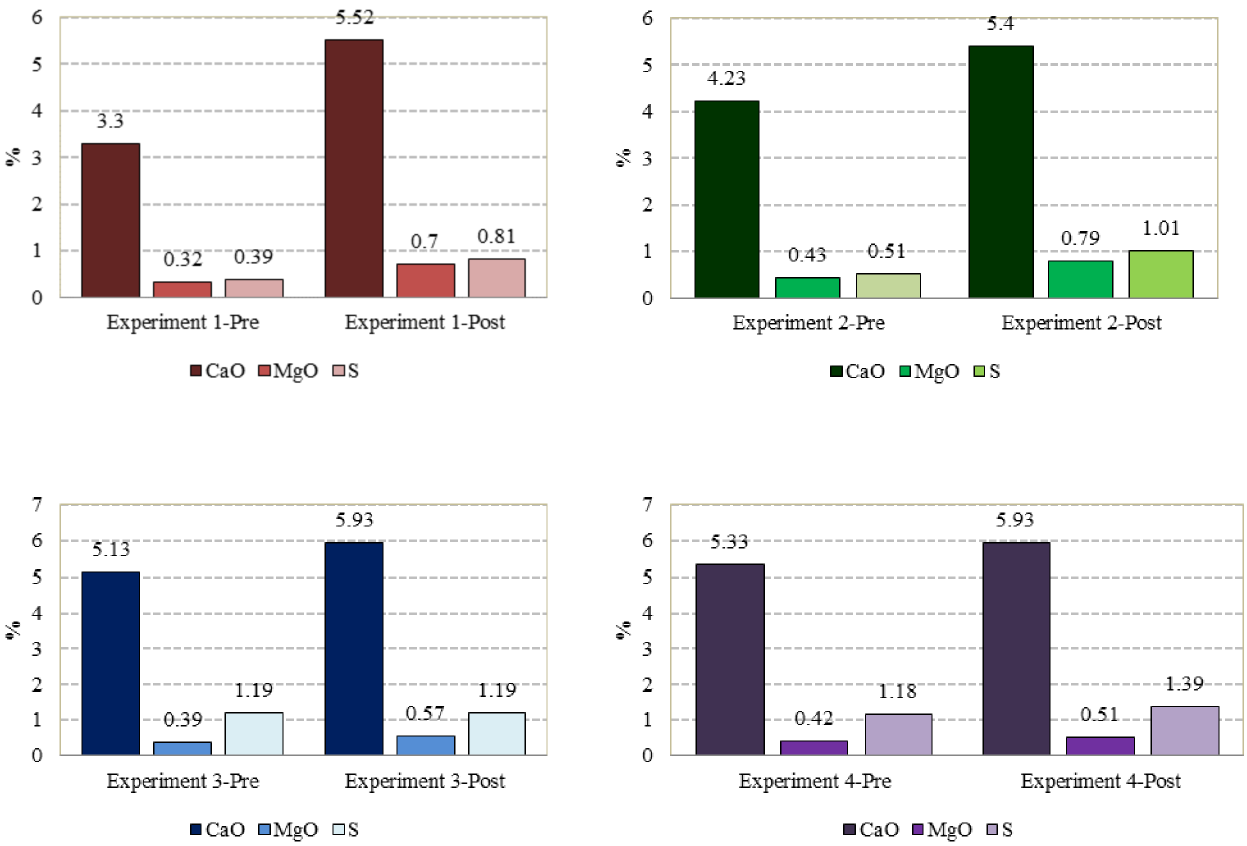

Fig.2 Pre-post micronutrients properties of composting products from four experiments.

Table 2 Percentage changes of nutrients for with and without urine

Nutrients	% changes of nutrients	
	Exp. 1 and Exp.2	Exp. 3 and Exp.4
N	-2.20	+4.64
P_2O_5	+31.30	+2.52
K_2O	+16.49	- 6.15
CaO	- 2.17	No change
MgO	+12.86	- 10.53
S	+24.69	+16.81

Remarks: (-) is the percentages of nutrients have decreased**.**

(+) is the percentages of nutrients have increased.

It is observed that nitrogen contents between FFMW composter (Experiment run 1 and 2) has decreased while the FS composter (Experimental run 3 and 4) has increased to 4.64%. Phosphorus in form of phosphorus pentoxide (P_2O_5) in both FFMW and FS co-composting processes have increased to 31.30 and 2.52%, respectively. And the potassium level in FFMW composter has risen to 16.49% while that in FS composter has declined to 6.15%.

From the results of micronutrients (K_2O, CaO, MgO, and S), there is no significant trend of nutrient changes from both composting. Therefore, there is no obviously effect on the nutrient contents from human urine addition except for the phosphorus content.

4. CONCLUSION

Fresh food market waste and faecal sludge have the potential on phophorus recovery and recycling. The final product properties from composting process are suitable for use in plantation or tree growing. Applying of human urine in composting processes have increased the content of phosphorus in form of phosphorus pentoxide (P_2O_5) to be about 31.30 and 2.52% in the FFMW and FS composter, respectively. This study suggests that FFMW and FS be widely utilized, especially for phosphorus recovery from the addition of urine as a means of moisture control in composting.

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