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Co-Composting of Palm Oil Mill Sludge-Sawdust

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Abstract: Composting of Palm Oil Mill Sludge (POMS) with sawdust was conducted in natural aerated reactor. Composting using natural aerated reactor is cheap and simple. The goal of this study is to observe the potential of composting process and utilizing compost as media for growing *Cymbopogun citratus*, one of Malaysia herbal plant. The highest maximum temperature achieved is about 40°C and to increase temperature bed, more biodegradable substrate needs to be added. The pH value decrease along the process with final pH compost is acidic (pH 5.7). The highest maximum organic losses are about 50% with final C/N ratio of the compost is about 19. Final compost also showed some fertilizing value but need to be adjusted to obtain an ideal substrate. Addition of about 70% sandy soil causes highest yield and excellent root development for *C. citratus* in potted media. Beside that, compost from POMS-sawdust also found to have fertilizer value and easy to handle. Composting of POMS with sawdust shows potential as an alternative treatment to dispose and recycle waste components.

Key words: Composting, palm oil mill, sludge, sawdust, *Cymbopogun citratus*

INTRODUCTION

Palm oil mill wastewater treatment plants produce huge amounts of sludge every year. This Palm Oil Mill Sludge (POMS) must be desludged from anaerobic or aerobic ponds to maintain efficiency of wastewater treatment. This sludge contains high moisture content and low carbon content, due to the high nutrient value. POMS will usually be dried and used as fertilizer (Chooi, 1984). Drying is done in open ponds but this process becomes a problem during rainy season due to slow rate of drying.

An abundant amount of sawdust is produced by wood industries. Sawdust is not easy to biodegrade and is usually burnt to dispose of it. According to Siddiqui and Alam (1990) sawdust is not favoured for soil conditioner due to high C/N ratio. Laos *et al.* (2002) using 17 and 25% of wood waste in composting fish and sewage sludge, respectively.

However, by adding nitrogenous source such as POMS, sawdust may be converted to a good soil conditioner (Siddiqui and Alam, 1990; Singh *et al.*, 1967). Addition of sawdust as amendment material improves efficiency of composting process by increasing porosity, retaining nutrient, reducing odor and providing additional carbon (Bhamidimarri and Pandey, 1996; Tiquia and Tam, 2000; Liao *et al.*, 1994). Therefore, in this study, composting of POMS mixed with sawdust was studied to find a suitable alternative way to treat and recycle these wastes. The composting process was done using natural aerated systems, which is less expensive compare to other composting system.

MATERIALS AND METHODS

Composting process: This study was carried out in Laboratory of Environmental Engineering, University Kebangsaan Malaysia between year 2003-2005. Sludge from anaerobic digestion pond was collected from Sri Ulu Langat Palm Oil Mill, Dengkil, Selangor, Malaysia. Sawdust was collected from various furniture factories around Bangi, Selangor. Recycled compost came from kitchen waste (Abd-Rahman and Mokhtar, 2000). Two kilogram recycle compost was added to facilitate composting process. Fifty two kilogram sludge and 28 kg sawdust were manually mixed. Mixture of POMS-sawdust was put in 0.3 m^3 static enclosed bin composter. Aeration to the composting mass was due to natural convective flow of air through uniformly distributed 2 cm diameter holes at the bottom of the bin.

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Sampling and physicochemical analysis: Temperature was measured at core of the reactor on day: 0, 1, 5, 10, 13, 19, 20, 25, 29, 34, 40, 45, 49, 55, 60, 70 and 90. Sampling was done by taking 40 g of compost at four different locations (0, 0.3, 0.6 and 0.9 m from bottom of the bin). The mixture was manually homogenised. Wet density was estimated by filling 500 mL beaker with material (Schulze, 1962). The pH was determined by adding 5 g sample to 50 mL distilled water, mixed with magnetic stirrer for 20 min, let stand for 24 h and then filtered. The supernatant was tested using pH meter (HI 931401, Microprocessor, pH meter, Hanna Instrument Ltd.). For moisture content, the mixture was oven-dried at 103°C for 24 h. Oven-dried sample were finely ground and screened to <0.5 mm to represent the whole sample homogenously. The Organic Matter (OM) was determined as volatile solid. Ash content was determined by burning dried sample at 550°C for 4 h (APHA, 1985). Total Organic Carbon (TOC) was determined by the following formula (Liao *et al*., 1994):

$$\text{TOC (\%)} = \frac{\text{Organic matter (\%)}}{1.8} = \frac{\text{Volatile solid (\%)}}{1.8} = \frac{100 - \text{ash (\%)}}{1.8}$$

Organic matter loss were determine using formula as given by Paredes *et al*. (2000):

$$\text{OM loss (\%)} = 100 - 100 \times (A/B)$$

Where:
A = % Initial ash content × (100 – % Final ash content)
B = % Final ash content × (100 – % Initial ash content)

Total Nitrogen (TN) was determined using the Kjeldahl method (Rowell, 1994) with C to N ratio determined as TOC/TN. After HCl digestion, P was determined volumetrically as ammonium phosphomolybdate and K determined using the cobaltnitrite method. Water holding capacity and pore size were determined using the Keen-Rackzoowski Box method (Iswaran, 1980).

***C. citratus* growth in potted media:** Growth studies were conducted to determine the suitable mixture of sandy soil to compost for growing *C. citratus*. Pseudostems of *C.citratus* were bought from market and submerged in tap water. After 3 days, *C.citratus* plants that had leaves approximately 0.5 cm long and roots approximately 0.5 cm long were transferred to 2 L plastic pots. Pots were filled with 0:100, 15:85, 25:75, 75:25 or 100:0 sandy soil (bought from hardware shop): POMS (by volume). Plants were placed on the cement floor. Every 2 days, plants were watered using tap water. No additional nutrient added to tap water. After 2 months, shoots were harvested and weighted.

RESULTS AND DISCUSSION

Physical characteristics of raw materials: The parameters of raw POMS and sawdust are given in Table 1. Addition of sawdust changed several parameters of POMS (Table 2).

Addition of sawdust reduced wet bulk density and moisture content significantly thus favouring composting, Moisture content of more than 70% can cause leaching in the composting process (Tiquia *et al*., 1996). C/N of 12 can cause volatilization of toxic free ammonia and thus may reduce microbial populations in closed reactor systems (Shin and Jeong, 1996).

Physicochemical evolution and organic matter loss: Temperature is the main indicator for a composting process (Nogueira *et al*., 1999). Maximum temperature for reactor was about 40°C (Fig. 1a). According to Anonymous (1996), the optimum temperature range is 32-60°C. After achieving maximum temperature (at day 15), the temperature in reactor decreased sharply. Secondary peaks in temperatures were possibly due to mesophilic organisms recommencing activity. Distinct troughs in the temperature may also be due to the excessive presence of ammonia and phenols, which inhibit bacterial growth and activity. Once most of the ammonia and phenols are released to the air, the bacterial population can

Table 1: Physicochemical analyses of raw POMS and sawdust

Parameters	POMS	Sawdust
Moisture content (%)	85.0	10
Wet bulk density (kg m^{-3})	1100.0	100
pH	8.4	5.8
Organic matter (% dry weight)	60.0	100
Total Organic Carbon (TOC) (% dry weight)	33.0	55
Total Nitrogen (TN) (% dry weight)	3.6	0.1
C/N	9.0	550
Phosphorus (as P_2O_5) (% dry weight)	0.9	0.001
Potassium (as K_2O) (% dry weight)	2.1	ND

ND: Not Determined

Table 2: Physicochemical characteristic for initial feed of POMS-sawdust composting

Parameters	Value	Reasonable range for composting
Wet density (kg m^{-3})	400.0	500-600 (Goldstein, 2002)
Moisture content (%)	58.0	40-65 (Rynk *et al*., 1992)
pH	7.5	5.5-9.0 (Rynk *et al*., 1992)
C/N	25.0	20-41 (Rynk *et al*., 1992)
Porosity (%)	73.0	>30% (Biddlestone and Gray, 1988)

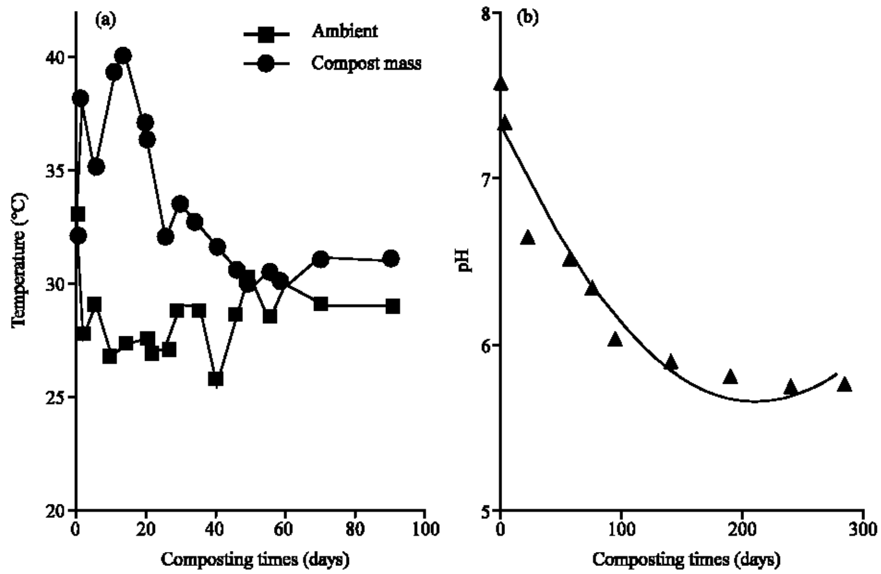

Fig. 1: Evolution of (a) temperature and (b) pH in composting of POMS-sawdust

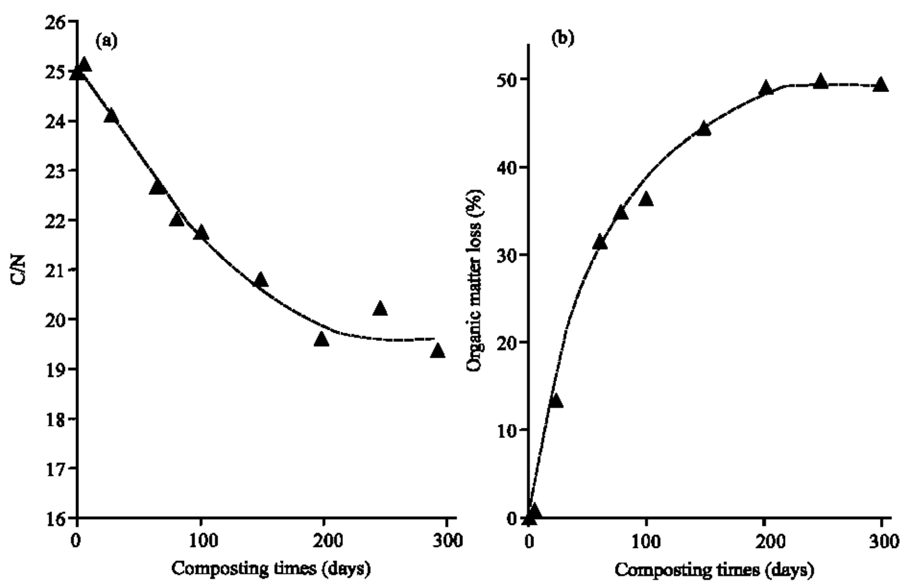

Fig. 2: Evolution of (a) C/N and (b) organic matter loss in composting of POMS-sawdust

resume growth, thus causing minor peaks in temperature (Liao *et al*., 1994). To achieve temperatures up to 50°C, more biodegradable carbon sources such as sucrose or green wastes need to be added to the compost mass (Qiao and Ho, 1997).

pH is relevant because microbial activity depends on pH and pH is an important parameter that can control nitrogen losses from ammonia volatilization (Qiao and Ho, 1997). In POMS-sawdust composting, the pH value decreased from 7.5 to 5.8 (Fig. 1b).

The initial C/N ratio of 25 decreased over the composting period to about 19.5, which is considered mature (Fig. 2a) (Jimenez and Garcia, 1989). Organic matter mineralistion and loss of CO_2 and H_2O cause decrease in C/N ratio (de Bertoldi *et al*., 1983). Morisaki *et al.* (1989) stated that nitrogen content also increased as sawdust retained the ammonia. Final compost with C/N ratio about 19.5 can accept as matured.

During composting, organic matter is found to be lost in all compost mass. The composting of most substrates is characterized by an initial period of rapid degradation followed by a longer period of slow degradation (Diaz *et al.*, 2002). Composting process achieved stability after 200 days. In 100 days, the organic matter loss is about 50% after 300 days composting (Fig. 2b). Fang *et al.* (1999) reported that 9% of organic matter was lost in composting sewage sludge-sawdust-fly ash in 100 days. Composting dewatered biosolid with wood waste reduced only 7-14% organic matter in 80 days (De Sales-Papa, 2002). Initial feed stocks that contain more easily biodegradable carbon sources cause higher organic matter loss. Composting olive mill sludge with agricultural wastes reduced maximum losses to 50-65% (Paredes *et al.*, 2002).

***C. citratus* growth in sandy soil with addition of POMS compost:** However, unsuitable quantities of compost can retard the growth of some plants due to phytotoxicity, salinity and compaction (Wilson *et al.*, 2002). In this study, the quantity of POMS-sawdust compost necessary to improve the growth of *Cymbopogon citratus* in sandy soil were to determine.

It can be determined that compost is stabile after 300 days composting (Fig. 2b). The final compost product had high nutrient content especially P and K (Table 3). However, the pH, water holding capacity and density of both compost need to be adjusted before they can be used as a substrate. Yield increased as composition of sandy soil increased until sandy composition about 70% (Fig. 3a). The relationship between yield and sandy soil composition was:

$$y = -4\times10^{-5}x^3 + 0.0047x^2 - 0.0749x + 2.737;\ r^2 = 0.99$$

Garcia-Gomez *et al.* (2002) reported that *Calendula* and *Calceoria* showed maximum yield when the composition of compost was 25-50% due to function of nutrient with low salinity. Wilson *et al.* (2002) stated that plants that are intolerant to salinity such as *Gloxinia*, *Justicia* and *Lysimacia* were retarded when composition of compost exceed 75%. The growth of roots also showed the same trend with highest growth of root observed in sandy composition about 70% (Fig. 3b). The relationship between root and sandy soil composition was:

$$y = -4\times10^{-5}x^2 + 0.0046x + 0.028;\ r^2 = 0.93$$

Table 3: Physicochemical analysis of final compost

Composition	POMS-sawdust compost	Recommended value for ideal substrate
pH	5.7	5.5-6.5 (Poole *et al.*, 1981)
Density (kg m^{-3})	410.0	600-1200 (Poole *et al.*, 1981)
Water holding capacity (%)	138.0	20-60 (Poole *et al.*, 1981)
Organic matter (% dw)	73.0	>80% (Abad *et al.*, 2001)
C:N (as TOC/TKN)	19.0	<20 (Jimenez and Garcia, 1989)
Phosphorous (as P_2O_5) (% dw)	0.9	>0.5 (Nogueira *et al.*, 1999)
Potassium (as K_2O) (% dw)	1.6	>1.5 (Nogueira *et al.*,1999)

dw: dry weight

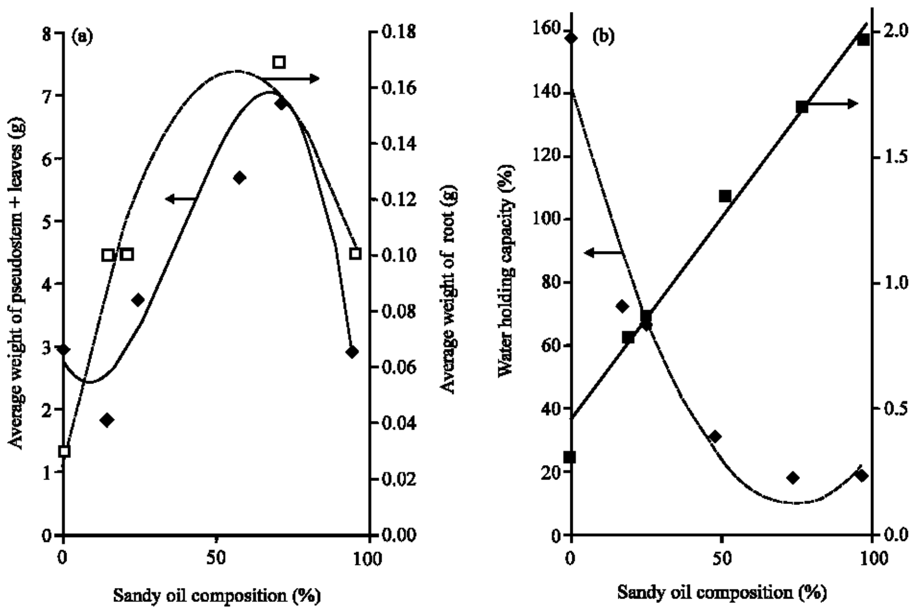

Fig. 3: (a) Average weight (pseudostem + leave) and root for *C. citratus* in various composition of POMS compost and sandy soil, (b) Change in water holding capacity and wet density in POMS compost after addition of sandy soil

The possible explanation for these phenomena is improvement of density (about 1500 kg m^{-3}) and water holding capacity (about 15%) of the media (Fig. 3b). Addition of substrate like sand and peat can decrease the phytotoxicity of compost (Keeling *et al*., 1994). After that, the weight of yield and root of *C. citratus* starts to decrease due to lack of nutrients

CONCLUSIONS

From this study, it can be concluded that composting of POMS with sawdust can be accomplished in a natural aerated reactor. Highest maximum temperature achieved was 40°C and to increase the temperature bed, more biodegradable substrate needed to added. The pH value decreased throughout the process with the final pH compost of 5.7. Highest maximum organic losses were about 50% with final C/N ratio compost of 19. Final compost also showed some fertilizing value but needed to be adjusted to obtain an ideal substrate. Addition of 70% sandy soil caused highest yield and root development for *C. citratus*. Composting of POMS with sawdust shows potential as an alternative treatment to dispose and recycle these waste components.

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