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The Effect of Weight Ratio on The Physiochemical Properties of Compost From Palm Oil Mill Effluent (POME) Sludge and Decanter Cake

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ABSTRACT

POME sludge and decanter cake can be utilized as compost fertilizer since it contains various nutrients which is essential for the plant to grow. In this work, POME sludge and decanter cake were mixed at different weight ratio in the range of 2:8 to 8:2 and undergo composting process for 60 days. Throughout the composting process, temperature is monitored to ensure that the sample has completed the process. After composting process completed, the matured compost is analyzed for chemical composition, pH, moisture content and water holding capacity. The temperature profile of composting shows a stable response between the time composted and the composting temperature. Meanwhile, the physical and chemical properties for sample with ratio of 5:5 (POME sludge: decanter cake) exhibit the best N, P, K ratio of 3:6:11 and other macronutrient and micronutrient compared to samples with ratio of 8:2 and 2:8.

INTRODUCTION

Malaysia is one of the top producers for palm oil and currently strengthening its palm oil production rate due to the increasing global demand for edible oil, biodiesel and oleo chemicals derived from palm oils. However, palm oil production had contribute to significant pollution especially river pollution because the palm oil mills usually discharged their effluents into rivers leading to the sea. Palm oil mill effluent causes serious land and aquatic pollution when discharged immediately into the environment (Nwoko and Ogunyemi, 2010).

POME sludge contains the suspended solids and dissolves solids which are left after POME treatment. The addition of thickened POME anaerobic sludge into compost material will enrich the compost materials with nutrient and microbial resources (Baharuddin *et al*., 2010). Apart from POME sludge, decanter cake is the other type of solid waste generated from the milling process of crude palm oil. It is produced when the crude palm oil is centrifuged for purification process. In this case, the supernatant is layer of the pure palm oil and the sediment is the decanter cake (Maniam *et al*., 2013). POME sludge and decanter cake are suitable to be used as fertilizer because both contain high moisture content which can further accelerate the rate of compost formation (Yahya *et al*., 2010).

Similar research has been conducted by Baharuddin *et al*. (2010) by using POME sludge and empty fruit bunch (EFB) for composting process. However, it was found out that the nutrient content of EFB is lower compared to decanter cake. A research by Yahya *et al*., (2010) has proved that the use of decanter cake in composting process is more preferred compared to EFB since the nutrient content is higher and able to enhance faster production of matured compost.

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Nowadays, industries are looking for cost effective sustainable technologies for disposal of industrial waste. The common process and technology that usually used is land disposal, where it helps to improve soil structure and nutrient status, leading to expectation of fertilizer replacement and extra yield (Rupani and Singh, 2010). Therefore, the best way to solve the problem with cheaper cost is by converting sustainable waste material from agricultural industry into valuable fertilizer through composting.

Methodology:

Preparation of Raw Material:

POME sludge and decanter cake are collected from LKPP Corporation Sdn. Bhd., Kuantan, Pahang, Malaysia. Both POME sludge and decanter cake were stored at room temperature before the experiment begins.

Analysis of Raw Material:

POME sludge and decanter cake sample were analyzed in order to study the initial properties of raw materials such as pH, moisture content, water holding capacity and chemical composition through elemental analysis.

a) pH:

In pH measurement, 5g of samples are added to 50ml distilled water. The solution is then mixed by using magnetic stirrer for 20 minutes and then filtered by using Whattman filer paper. After that, the supernatant were tested by using pH meter (METTLER TOLEDO S20 SevenEasy) in an aqueous solution.

b) Moisture Content:

For moisture content analysis, POME sludge and decanter cake were weighed (wet weight) before dried in an oven (Memmert UFE500) at 110˚C for 24 hours to reduce the moisture contain in the sample. Then, the samples were removed from the oven and weighed it again.

c) Water Holding Capacity:

For water holding capacity properties, 100ml water is pour onto the 100g sample in a pot and kept in a slanting position. When water drops stop from coming out, the sample was removed and weighed immediately. Before the dry weight of the sample recorded, it was dried at 105°C for 48 hours in an oven (Memmert UFE500).

d) Elemental Analysis:

CHNS and X-Ray Fluorescence (XRF) analyzer were used to check the composition of element. CHNS analyzer function is to detect nitrogen (N) element. Meanwhile, XRF is used to detect phosphorus (P) and potassium (K) element. For elemental analysis, POME sludge and decanter cake were heated in an oven at 110˚C to reduce moisture contents. The dried samples of POME sludge and decanter cake were grinded before it was analyzed by using CHNS analyzer and X-Ray Fluorescence (XRF) analyzer.

Experimental Procedure:

In this work, POME sludge and decanter cake are mixed at different weight ratios (8:2), (5:5) and (2:8) in a cylindrical container to facilitate the composting process. Manual turning and aeration was done once a week for sufficient aeration and material mixing. During composting process, the temperature of compost were monitored daily for 60 days. Besides that, moisture content of the compost were controlled to make sure the samples receives optimum water content so that rapid decomposition will occur. When the samples are no longer generating heat after mixing, it was allowed not to do the mixing process.

Analysis of Samples:

The matured compost samples will be analyzed by using the same procedure used for analyzing the raw materials.

RESULTS AND DISCUSSION

Temperature Profile of Compost:

Temperature plays an important role in determining the completion of composting process. According to Cooperband (2002), ambient air temperatures affect microbial growth and activity in the compost pile. The optimal temperature of compost pile is commonly to be between 54.4˚C to 65.5˚C (Chen *et al*., 2009).

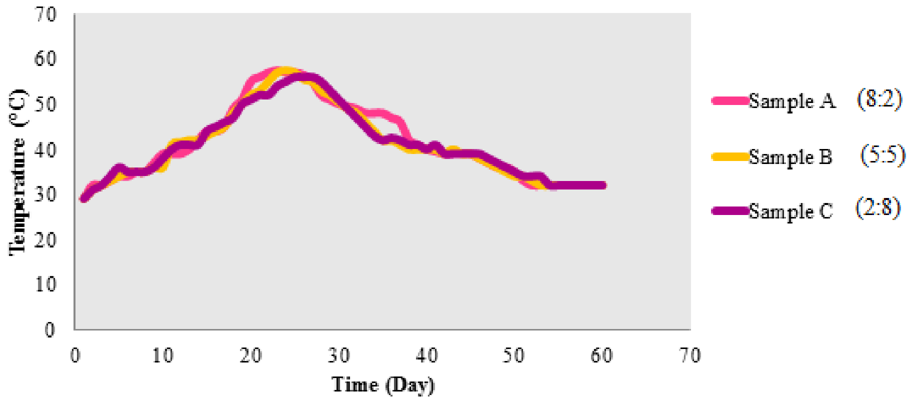

Fig. 1: Profiles of compost temperature throughout composting period in 60 days.

Based on Figure 1, for the first 11 days, the temperature of compost increased slowly up to 40˚C. At this stage the process is called mesophilic phase, in which the decomposition process by microbes begins to accelerate (Thomsen, 2002).

According to Anand *et al*. (2012), the maximum composting activity may be achieved in thermophilic conditions with the temperatures in the range of 50-60˚C. At the first 11 days, the temperature continuously increased until it reached the maximum temperature of 57.5˚C at day 24. This is due to the heat released resulted from the decomposition process (Walker *et al*., 2009).

The temperature of the compost starts to reduce below 40˚C to ambient temperature after day 38. Condition where the temperature decline closed to the ambient temperature is known as curing phase (Cooperband, 2002). During the curing phase, the chemical reactions continue to occur making the remaining organic matter more stable and suitable for plant use (Hoitink, 1998).

Chemical Properties of Compost:

a) N, P, K Composition:

By using X-ray Fluorescence (XRF) analysis and CHNS analysis, the major content such as nitrogen (N), phosphorus (P) and potassium (K) contain in the raw materials and compost were determined. The result of elemental analysis is shown in Figure 2.

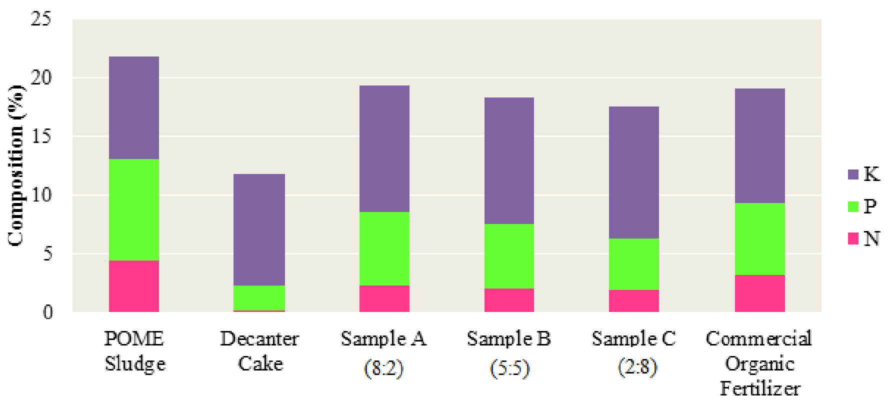

Fig. 2: N, P, K composition in raw materials and composts.

Figure 2 shows the results of elemental analysis of POME sludge, decanter cake and compost sample. Based on elemental analysis on POME sludge and decanter cake, it was found that the phosphorus and nitrogen content in POME sludge are much greater than decanter cake. On the other hand, the potassium content in decanter cake is slightly higher than the POME sludge. Therefore, the combination of POME sludge and decanter cake complement to each other in order to achieve optimum ratio between N, P, K.

Based on Figure 2, sample A has the highest nitrogen content, which is about 2.4%. This is due to high amount of POME sludge that increased the content of nitrogen in sample A. Meanwhile, sample C has the lowest nitrogen content for about 1.93% as the decanter cake has low nitrogen content. In overall, nitrogen content in all the samples are lower compared to the other element contents. However, nitrogen content will increase if the amount of POME sludge in the sample increase. According to Allen (2014), composition of nitrogen between 0.75% and 2.5% is normal. A research by Baharuddin *et al*. (2010) also reported that after the addition of POME sludge to composting pile, the nitrogen content in the compost has increased from 0.93% to 2.31%.

Larger amount of POME sludge contributes to higher composition of phosphorus. Sample A contains 6.2% of phosphate composition which is similar to commercial organic fertilizer. In fact, it has higher phosphate compared to sample B and C. High amount of phosphorus is essential for plants because phosphorus helps to store and use energy from photosynthesis to develop roots, speed maturity and resist stresses (Zekri and Obreza, 2012).

Meanwhile, sample C contain the highest potassium content compared to sample A, Sample B and commercial organic fertilizer due to larger amount of decanter cake in the formulation. According to a research by Yahya *et al*. (2010), the addition of decanter cake is able to produce higher content of potassium by 17.7%. Potassium is an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism (Wang *et al*., 2013). Thus, high amount of potassium brings benefit to the plants growth.

b) Micronutrients and Macronutrients Composition:

Nutrients serve numerous functions to plants. Apart from nitrogen (N), phosphorus (P) and potassium (K), the raw materials and finished compost also contained secondary macronutrients such as Calcium (Ca) and Magnesium (Mg). Besides that, micronutrients also present in the sample such as Silicon (Si), Iron (Fe) and Manganese (Mn). The result of nutrients in raw materials and composts by using elemental analysis is shown in Figure 3.

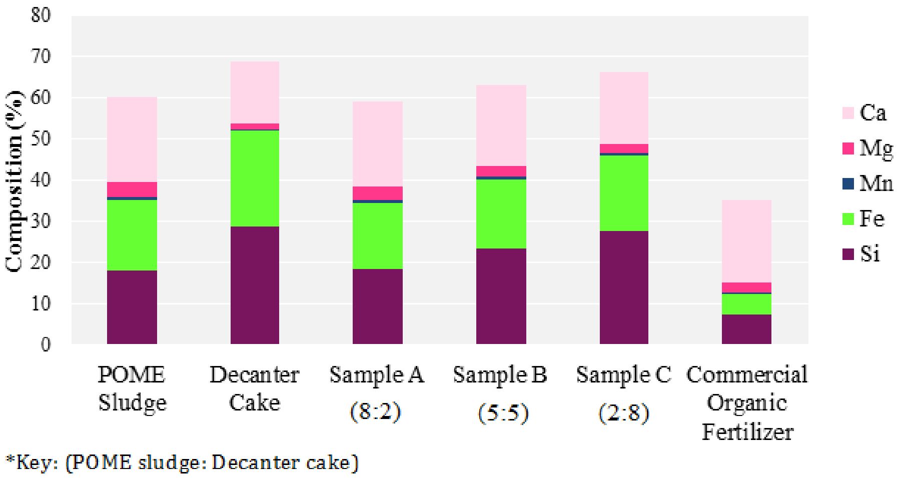

Fig. 3: Nutrients in raw materials and composts.

Based on Figure 3, compost with larger amount of decanter cake shows the highest composition of silicon. According to Ma (2004), silicon alleviates physical stresses including salt stress, metal toxicity, drought stress, radiation damage, nutrient imbalance, high temperature and even effective in controlling diseases caused by both fungi and bacteria in plant. Silicon is deposited as silica in the plant cell walls, improving cell wall structural rigidity and strength, plant architecture and leaf erectness (Smith, 2011).

In plants, major functions of calcium are related to its capacity to form coordinate bonds, and its ability to establish stable but reversible intramolecular and intermolecular linkages, especially in the cell wall and at the surface of membranes (Grusak, 2002). Calcium is one of the macronutrients that highly presence in POME sludge compared to decanter cake. Thus, compost with large amount of POME sludge contains higher amount of calcium which essential for the plants. In fact, the content of calcium in Sample A are very close to the calcium presence in commercial organic fertilizer.

Besides silicon and calcium, iron is also one of the major micronutrients in composts. Figure 3 shows that decanter cake has higher iron content compared to POME sludge. Therefore, compost with larger amount of decanter cake has higher iron content. However, iron contents were decreasing in all the samples after composting process. Most of the nutrients and metal ions were decreasing in the later stages of composting, which is due to leaching of ions with the water present in the solid waste (Manohara and Belagali, 2014).

Magnesium influenced particular metabolic processes and reactions in plant such as photophosphorylation, photosynthetic carbon dioxide fixation, protein synthesis, chlorophyll formation, phloem loading and photo-oxidation in leaf tissues (Cakmak and Yazici, 2010). From Figure 3, POME sludge contains higher amount of magnesium compared to decanter cake. Thus, samples with larger amount of POME sludge have higher magnesium content and are better than commercial organic fertilizer.

Apart from that, manganese also present in small quantities in raw materials and sample. Manganese is an essential element for plants, intervening in several metabolic processes mainly in photosynthesis and as an enzyme antioxidant-cofactor (Millaleo and Reyes-Diaz, 2010). Figure 3 shows that sample with larger amount of POME sludge contains higher amount of manganese. This is because POME sludge contains larger amount of manganese compared to decanter cake.

Physical Properties of Compost:

For physical properties of compost, pH, moisture content and water holding capacity were measured. The results are tabulated in Table 1.

Table 1: Physical properties of compost.

	Raw Materials		Weight Ratio (POME sludge: decanter cake)			Commercial Organic Fertilizer
	POME sludge	Decanter cake	Sample A (8:2)	Sample B (5:5)	Sample C (2:8)	
pH	7.60	6.70	7.00	7.00	7.00	6.50
Moisture content (%)	81.16	71.41	48.90	47.30	45.30	n.a
Water holding capacity (ml/100g)	18.67	40.32	24.53	36.85	50.21	11.58

*n.a = not available

The pH value of compost is important, since applying compost to the soil can alter the soil pH which in turn can affect the availability of nutrients to the plant (Watson, 2008). Based on Table 1, the pH of all composts became neutral at pH 7.0 after 60 days of composting and perhaps are better than commercial organic fertilizer where the pH are 6.5. According to Allen (2014), the pH of finished compost should be neutral (7.0).

From Table 1, finished compost contains moisture content ranged from 45.3% to 48.9% which was lower compared to the moisture content of fresh raw materials. High thermophilic temperature and frequent turning in the composting piles contributed to water loss (Baharuddin *et al*., 2010). As for commercial organic fertilizer, the moisture content information is not provided by the manufacturer.

Water holding capacity refers to the amount of water held by plants (Vengadaramana and Jashothan, 2012). According to Schoonover and Crim (2015), soils with a higher amount of organic matter and a large percentage of micropores generally have a higher water holding capacity. Based on Table 1, compost with larger amount of decanter cake has the highest water holding capacity. This result is related with the result of nutrients in Figure 3 where large amount of silicon in decanter cake alleviates drought stress as stated by Ma (2004). This is due to the hydrophilic nature of silica which can decrease the poisonous level of saline ions and reduce the osmotic effect of salt stress on the absorption and storage of water (Mahbod *et al*., 2014). A research by Matichenkov and Bocharnikova (2001) reported an increase in the water holding capacity of soils with varying textures after a month of incubation with silicon−rich materials. As for commercial organic fertilizer, the water holding capacity is the lowest due to low amount of silicon content compared to the other samples.

Conclusion:

In conclusion, the combination of POME sludge and decanter cake are found to be a good choice to produce balance nutrient of compost because both material plays important roles in the contributing the essential nutrient for the plant. It is found that the formulated compost are comparable to the commercial organic fertilizer in terms of chemical composition where sample B with ratio of 5:5 (POME sludge: decanter cake) exhibit the best N, P, K ratio of 3:6:11 and other macronutrient and micronutrient content. In terms of physical properties, it is shown that the formulated compost have better properties compared to the commercial organic fertilizer.

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