2012 International Conference on Environmental Science and Technology
IPCBEE vol.30 (2012) © (2012) IACSIT Press, Singapore

Waste Minimization: Utilization of Palm Oil Mill Wastes by Vermicomposting Technique

Parveen Fatemeh Rupani [1+], Asha Embrandiri [1], Shlrene quaik[1,] M. Hakimi Ibrahim[1]

[1] School of Industrial Technology, Universiti Sains Malaysia, 11800, Pulau Pinang, Malaysia

Abstract. The total oil palm cover has increased in the past few years in Malaysia with increasing the palm oil mill production. Palm oil mill wastes such as palm oil mill effluent (POME) and palm oil mill fiber (POMF) are the main byproducts of the milling process. Palm oil mill effluent is a thick brownish liquid that contains high solids, oil and grease, COD and BOD values. Although POME is organic in nature, it is difficult to decompose in natural conditions. By taking this into account, POME considered as source of organic waste and it can convert into a value added product by the help of earthworms. Aim of this research was to study the potential of using vermicomposting process for POME and POMF. The experiment was carried out in laboratory condition for 45 days by adding epigeic earthworm, Lumbricus rubellus, into 2000 g of (1:1) ratio of substrate material. Physico-chemical analysis was done throughout the vermicomposting process. The data revealed that the vermicomposting technique is suggested as a good alternative sustainable management of palm oil mill effluent absorbed with fiber effective treatment of POME absorbed with fiber and convert it into valuable products such as organic fertilizer.
Keywords: POME, POMF, earthworms, vermicomposting

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1. Introduction

Indonesia and Malaysia are the two largest oil palm producing countries. Malaysia has a tropical climate and rich in natural resources. Oil palm currently occupies the largest acreage of farm land, while rubber and coconut cultivation is decreasing in Malaysia (Figure1). It is believed that this will continuously increase along with the world demand of edible oils. In 2006 the total area under oil palm cultivation increased to about 4.05 million hectares, with the total palm oil production of 16.8 million tonnes [1]. In 2004, it was estimated that from 381 palm oil mills in Malaysia, 26.7 million tonnes of solid biomass and average of 30 million tonnes of palm oil mill effluent discharged from the industries.

Palm oil mill effluent (POME) characterized by brownish colloidal suspension contains high concentrations of organic matter, high amounts of total solids (40,500 mg L^{-1}), oil and grease (4,000 mg L^{-1}), COD (50,000 mg L^{-1}), BOD (25,000 mg L^{-1}) and low pH ranging between 4 and 5 [2]. Discharging the effluent and by-products on the lands results in environmental pollution and deteriorates the surrounding environment. Therefore, there is an urgent need for an efficient and different management system for the treatment of these by-products.

Several researches proved the potential use of earthworms in nutrient recovery from industrial by-products. It has confirmed the vermicomposting technology as a cost effective solution for disposal of organic wastes. During vermicomposting, essential nutrients converted from the organic material, are released [3]. Vermicomposting results in vermicasts, a useful material from organic waste by means of earthworms, and at the same time minimizing pollution [4]. Vermicompost is a final peat-like material with excellent structure, porosity, drainage and moisture holding capacity [4, 5].

[+] Corresponding author. Tel.: + 60124559162
E-mail address: pfr09_tec090@usm.student.my

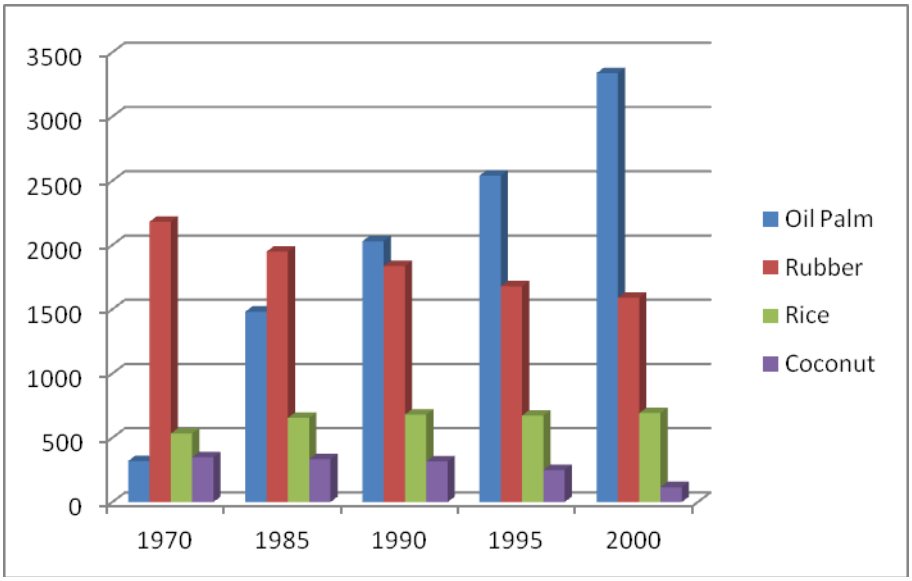

Fig. 1: Malaysia- Agriculture acreage 1970-2000 [1000 Heectares] [6].

In this study *lumbricus rubellus* used as epigeic earthworm as it has potential to convert the organic wastes into the value add products. As POME contains 85-95% water, thus, in order to obtain appropriate physical environment for the earthworms' growth, there is a need to integrate the POME with oligo-cellolusic materials such a palm fiber. From the literatures, it is evident that there is limited data available on vermicomposting of POME as an organic waste and convert it into value added product. This paper reports the feasibility of vermicomposting of POME mixed with POMF employing the composting worm, *L. rubellus.*

2. Experimental outline

2.1. Methods and Material

POME and POMF obtained from the Palm oil mill plant (Malpom industries Sdn Bhd in Penang, Malaysia). All the experiments were conducted in the vermitechnology laboratory at room temperature, at the School of Industrial Technology, Division of Environmental Technology, USM, Penang, Malaysia. The experiment was carried out in vermireactors (24cm x 24cm x 24cm). POME was mixed with OPMF (20% moisture) in a ratio of 1:1 w/w. the mixture maintained to 80% moisture.

2.2. Manuscript Chemical analysis

Sampling was done periodically at 7 days interval from each vermireactors and some parameters such as temperature, pH and electro conductivity (EC) (determined in 1:10 w/v), total organic carbon (TOC) by a Shimadzu TOC Solid Sampler Module, the SSM-5000A connected to a TOC-VCSH, and total nitrogen (Kjeldahl method) [7] were analyzed. Temperature was measured at core of the reactor every 3 days interval until the end of 45th day.

2.3. Statistical analysis

One way ANOVA were analyzed by using PSAW statistics 18 and all values presented as the mean ± SD (standard deviation). The probability levels used for statistical significance were $P < 0.05$.

3. Result and discussion

Due to the acidic nature of POME (pH= 4), palm oil mill fiber was added in 1:1 ratio in order to make an edible substrate for the earthworms with the pH of neutral. The characteristics of POME and palm oil mill fiber are illustrated in Table 1. Samples were precomposted for two weeks as suggested by Gundai (2002) [8],as a strategy for reducing the pathogens in waste materials. Also Mupondi (2011) [9] reported, precomposting for long duration results in microbial population and diversity that results in less nutrient for earthworms and reduce value of the vermicomposting phase.

Table 1: Properties of Palm oil mill effluent (POME) and palm oil mill fiber (POMF)

Parameters	POME	POMF
Moisture %	95	20
pH	3.9	5.9
C (%)	31.5	42.7
N (%)	3.8	0.8
C/N	8.3	50.8
COD[a] (mg/L^{-1})	40,563.0	-
BOD[b] (mg/L^{-1})	15,100.0	-

[a]Chemical oxygen demand (COD), [b]Biological oxygen demand (BOD)

The final vermicompost was darker in color, pleasantly earthy in odor, granular and homogeneous than the initial feed mixture after 45 days of earthworm activity. The physico-chemical analysis has been done during the vermicomposting process. As it is illustrated in Figure 2 pH value decreased from alkaline (7.62-7.52) to slightly acidic (6.85-6.98) in the vermireactors. Bioconversion of organic material and mineralization of nitrogen and phosphorus caused the pH reduction in the final vermicomposted material [10, 11].

Electro conductivity (EC) was increased through vermicomposting process in this experiment. Kaviraj and Sharma (2003) described this increase in EC might have been due to loss of organic matter and release of phosphate , ammonium, potassium etc [12].

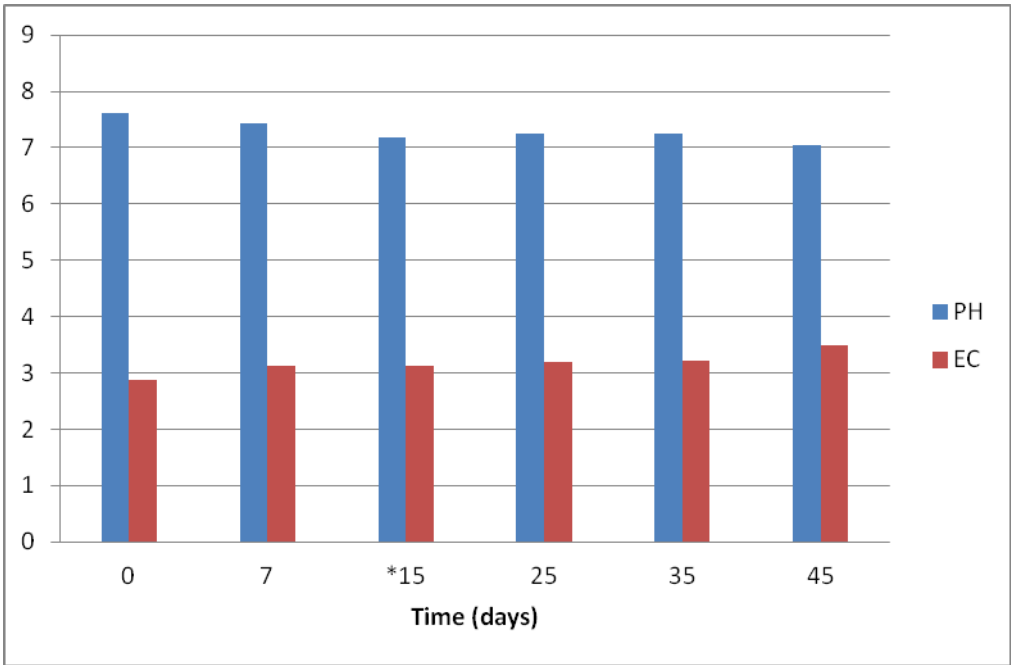

Fig. 2: pH and EC value during the vermicomposting process.

*Time of adding the earthworm in vermireactors.

Mineralization of organic matter during the vermicomposting process cause total organic carbon (TOC) loss in vermireactors [13]. As illustrated in Figure 2, reduction of TOC was from 35% to 30% in the final vermicompost.

Total Kejldhal Nitrogen (TKN) increased in final vermicompost from 0.93% to 1.76% Figure 3. Tripathi and Bhardwaj (2004) [14] reported that increase in total nitrogen might have been due to incorporation of

mucus, nitrogenous excretory and enzymes by the earthworms. The trend of increasing the N value is also same by other authors [14, 15]

The process of respiration and production of mucus leads to reduction of CN ratio through vermicomposting process [15]. Moreover, CN ratio is the indicator of the maturity of organic compost. It is evident from Figure 2 that the final CN ratio decreased to 17.2 that is a measure of humic material formation and enhanced stability to microbial composition [16, 17].

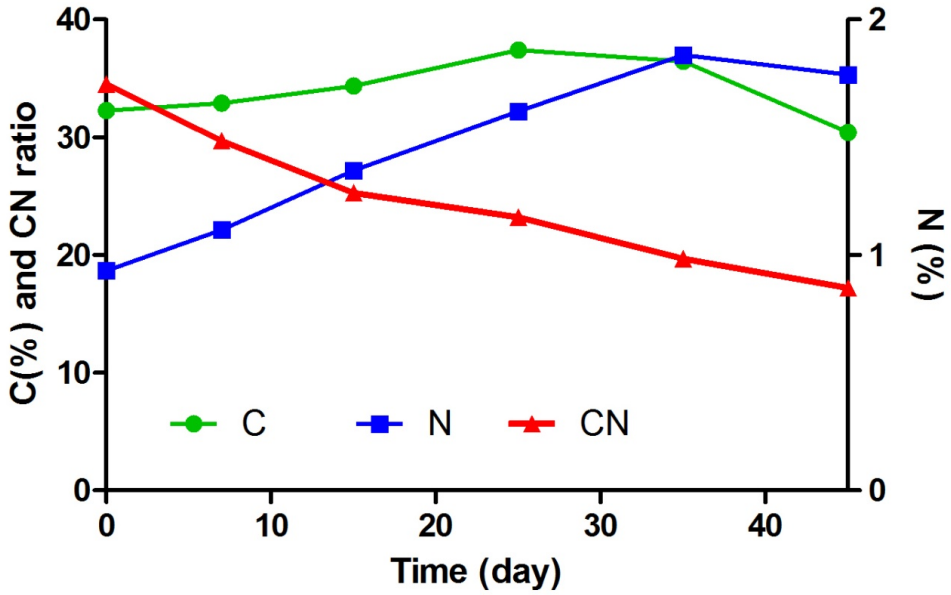

Fig. 3: Illustrate Total Organic carbon (TOC), Total Nitrogen and C: N ratio of the substrate through vermicomposting process. All the values are in percentage.

C: N ratio below 20 indicates an advanced degree of maturity of organic wastes [18]. So, in this work a high degree of organic matter stabilization was attained. This shows the role of earthworms in decomposition and mineralization of organic matter.

4. Conclusion

Palm oil mill industry produces large amount of wastes such as palm oil mill effluent (POME) and palm oil mill fiber (POMF). Disposal of these wastes results in environmental pollution as well as contaminating the ground water. Therefore, there is an urgent need for management of these byproducts. This study shows the feasibility of vermicomposting of these byproducts convert it into value added product. As a result these byproducts should no longer treat as wastes as they are source of organic matter. The relatively lower C: N ratio of the final vermicompost makes it suitable as a soil conditioner in agricultural fields. Addition of cattle dung is suggested for future work in order to enhance the vermicomposting process.

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