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Biocomposting Process for Utilization Agro-Industrial Wastes

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Abstract

Biological treatment has played prominent roles in bioremediation of wastes and contaminants. Composting is one of the biological process that has been considered to be one of the most suitable ways of converting organic wastes into products that are beneficial for plant growth. The study of the bio-composting process by solid-state bioconversion utilizing palm oil mill effluent (POME) and empty fruit bunch (EFB) were studied in lab scale. From the study it is found that horizontal rotary drum bioreactor was the most suitable to run this study. In this project, four filamentous fungi were used; (i) *Phanerochaete chrysosporium*. (ii) *Trichoderma harzianum.* (iii) *Aspergillus niger.* (iv) *Penicillium sp.* The bioconversion of lignocellulosic materials by evaluating the C/N ratio and other parameters using horizontal rotary drum bioreactor were studied. The good and mature of the compost is reflected by C/N ratio, germination index and glucosamine assay. The result showed that the C/N ratio drop from days 10 onwards and in the range of 25 to 30. The germination indexes of 50 to 70% indicate that the compost produce was a phyto toxic-free product and merely achieved as mature compost. The composting period required to complete this process was two months. Thus, this study developed an effective and feasible composting technique of POME and EFB using horizontal rotary drum bioreactor by solid state bioconversion process.

Keywords: POME, Compost, Microorganisms, EFB, GI

1.0 Introduction

It is recognized that the revenue from palm oil industry has contributed much towards Malaysia's income, the rapid expansion of the industry also contributed on the environment pollution. The production of crude palm oil involves mechanical extraction process in which the fresh fruit bunches undergo sterilization, digestion and extraction of the oil. However, all of these processes generate palm oil mill effluent (POME) in which affecting the environment [1]. POME, with an average Biochemical Oxygen Demand (BOD) of 25 000 mg/L for every tone of palm oil produced, it is a thick-brownish colloidal slurry of water, oil and fine suspended solids. It is hot (80-90°C) fresh, acidic (pH 4-5) and contains a very high organic matter content as indicated by its high BOD (about 100 times that of sewage) [2]. The suspended solids in POME are mainly oil-bearing lignocellulosic materials that come from fruit. Lignocellulosic is the major structural component of woody plants such as grass and represents a major source of renewable organic matter. Lignocellulosic consist of lignin, hemicellulosic, and cellulosic material. The chemical properties of the components of lignocellulosic material make them a substrate of enormous biotechnological value. For instances, the oil palm biomass (OPB) produces about 40 million tonnes per year. This OPB

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can be categorized as a form of empty fruit bunches (EFB), oil palm trunks (OPT) and oil palm fronds (OPF) and the rest are palm oil mill effluent (POME). There are 7.0 million tones of oil palm trunks, 26.2 million tones of palm oil fronds and 23% of empty fruit bunch (EFB) per tone of fresh fruit bunch (FFB) processed in oil palm mill for replantation after about 20 to 25 years [3]. Much of the lignocellulosic waste is disposed by biomass burning, which is not restricted to developing countries alone, but it is considered a global phenomenon. In addition, the problem arises when all of this biomass is not being treated and left to rot in the plantations to provide some nutrient. Unfortunately, these wastes may create the environmental problems later due to high organic content accumulate on the ground. Therefore, environmental management is placing the greatest emphasis in waste minimization at source or recycling. Moreover, a growing awareness of the need not to pollute has forced this industry to look more closely at the milling operation. Composting is a method that is increasingly used for treatment of organic waste. The composting process has been defined as the biological degradation of organic constituents in wastes under controlled conditions [4]. The process has many advantages including sanitation, mass and bulk reduction, and decrease of carbon (C) to nitrogen (N) ratio (C/N). The stabilized compost produced should benefit plant growth and be suitable for agricultural applications [5].

2.0 Materials and Methods

2.1 Substrates and Co-substrate

Palm oil mill effluent (POME) and oil palm biomass (OPB) were obtained from a local palm oil mill manufacturer (Seri Ulu Langat Palm Oil Mill at Dengkil, Selangor). Co-substrate used in the experiment was wheat flour, for effective biodegradation of STP (sewage treatment plant) sludge compost using filamentous fungi [6].

2.2 Fungal Strain

Four different types of microorganisms had been used, served different function in biodegradable process. There were *Penicilium*, *Aspergillus*, *Tricorderma*, and *Phanerochaete chrysosporium*. The fungi were separated and maintained on Potato Dextrose Agar (PDA) plates for spore production and were incubated at 32°C until the entire plate is discovered by fungus. The best grow of the fungus were at seventh day.

2.3 Rotary drum bioreactor description

Rotary drum bioreactor (Solid state fermenter) as seen in Figure 1 of Total volume of 70 L, Working volume = 50 L, and of Dimension of vessel = 600mm x 315 mm

2.4 Sample collection

Samples of POME and EFB were collected from Seri Ulu Palm Oil Processing Mill, Dengkil, Selangor. For POME, we have collected fresh POME that flowing through right after the process. EFB and POME were stored in 4^{o}C for further use. For this project no sterilization takes place for composting process.

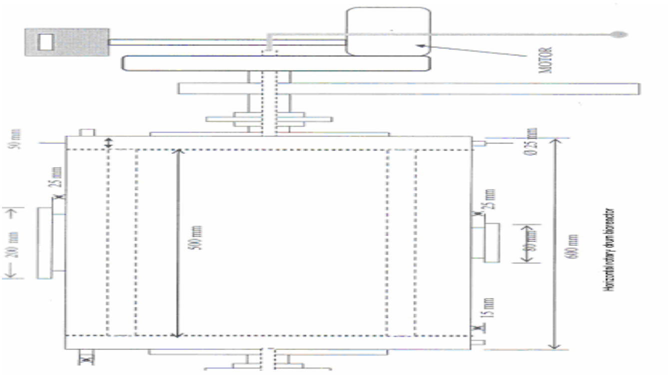

Figure 1 Horizontal rotary drum bioreactor

2.5 Experimental procedures

According to the research done, 50 L capacity of solid-state horizontal rotary drum bioreactor is used. The period of incubation was two months where the sampling will be taken from 0, 10, 20, 30, 40, 50 and 60 day. Fermentation was done inside the solid-state horizontal rotary drum bioreactor. The process conditions set up for the process were maintained, included the pH which is in the range 5-7, temperature was at the ambient temperature (30 $\pm$ 2 ^{o}C), the moisture condition at 60-70%, the agitation was 10 minutes per day, and the aeration was 1 hour per day. The inoculum used was cultured inoculum about 5-10%.

3.0 Results and Discussion

The experiment was carried out in the horizontal rotary drum bioreactor with the substrate and co-substrate which undergoes composting process for 60 days. Several fungi were inoculated inside the bioreactor that affects the result of compost. The mixing of the compost was done by rotating the bioreactor at 10 rpm for 10 minutes once a week through agitation. Whereby, the aeration was accomplished by means of air compressor in which the air is sterilized by bubbling through sulphuric acid (2%) everyday.

3.1 C/N ratio

Wang et al. described that the C/N ratio is an index traditionally used to evaluate the maturation of the end product (compost) of bioconversion, but the value cannot be used as an absolute indicator of compost maturation [7]. The maturity of the compost is the important parameter in compost production process and its application. One of the practical ways is using C/N ratio evaluation, the C/N ratio is also widely used as an indicator of compost maturation and should become stable with time.

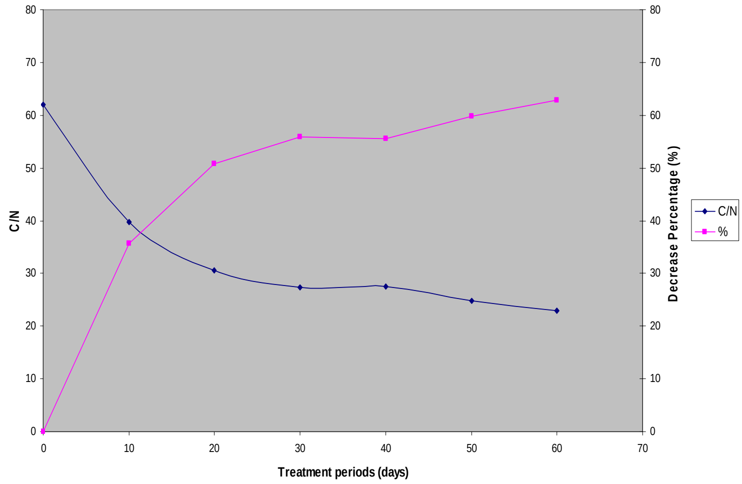

Figure 2 Changes in C/N ratio profile of composting process

At zero day, the C/N ratio is around 70 indicated that it is high with carbon and less nitrogen content. However, as composting time goes, the C/N ratio drop to 27 at day 20 and keep decreasing onwards. According to Heerden et al, a value of C/N ratio less than 20 could be considered as a satisfactory maturation level of compost [8]. However Jiménez et al notified the ratio of 15 or less is more preferable [9]. Wang et al stated the final range of C/N ratio of 17-19 over 100 days composting of sewage sludge, which was 25 initially in pile composting that did not have any microbial treatments [7]. However from Figure 4.10, the C/N ratios were in the range of 25 to 30 for 60 days of composting period and if the treatment period is elongate some more days, good result will be obtained. [10], introduced a 70 days composting program of soybean leaves, the final range of C/N ratio 18-22 was achieved when the initial ratio was 30. Mathur et al. expressed that the ideal C/N ratio of mature compost is 10, as in humus, hardly ever achieved by composting[11]. In spite of this difficulty, they also remarked that C/N ratio up to 20 is acceptable for composts as long as they are bio-table or mature. They added that C/N ratio itself cannot be used as a sole indicator of biomaturity for all types of composts.

3.2 Germination Index (GI)

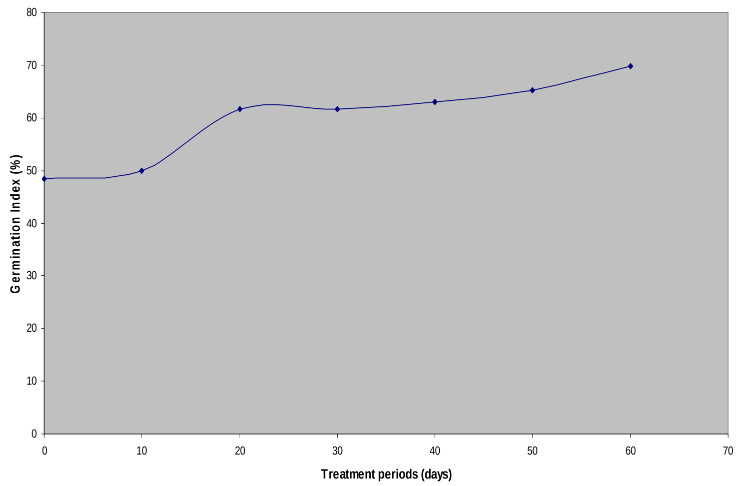

Figure 3 Germination Index

Germination index (GI) is the most sensitive parameter used to determine the level of toxicity of composts to seedlings and it is to test if the compost is mature [12,10]. In Figure 3, the GI was at 48% in the zero days and slightly increased to 50% at day 10 of composting. By the inoculation of *Penicillium* at day 45, the GI was slightly increased to 60% and continuously increased within the treatment period. A GI value of 50 % has been used as an indication of phytotoxic-free compost [12], and a GI of more than 80 % is considered mature compost [13]. From this result, it can be concluded that the compost product is phytotoxic-free but yet is immature.

3.3 Glucosamine assay

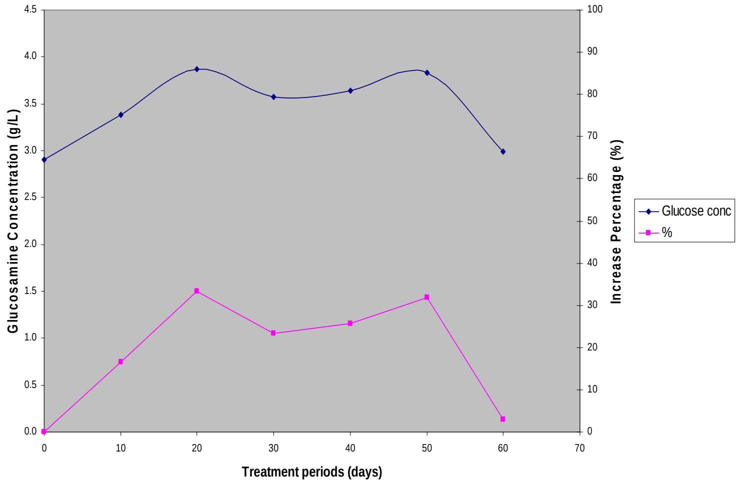

Figure 4 Glucosamine assay as biomass indicator

From the Figure 4, the glucose increased at the initial phase (day 10 and day 20) before it started to decrease between days 20 to 40 of composting time. The glucose concentration was increased at day 50 before started to decrease at day 60. This can be related due to the reduction of nutrients for the growth of fungi. It was a good compound to estimate the produced biomass from microorganism's growth. Molla et al. described that glucosamine can be considered as a good parameter for estimation of the mycelia growth in solid substrate[6]. Where, glucosamine is an essential component in chitin of mycelia cell wall, is a water soluble sugar and stable component. The accuracy of the glucosamine method in determining the fungal biomass depends on establishing a reliable conversion factor relating glucosamine to mycelia dry weight [14].

4.0 Conclusion

The study of the bio-composting process by solid-state bioconversion utilizing palm oil mill effluent (POME) and empty fruit bunch (EFB) were studied in lab scale. From the research it is found that horizontal rotary drum bioreactor was the most suitable to run this study. Moreover, the batch process was conducted to run the experiment under unsterilized. The study was carried out by utilizing POME and EFB as a main substrate, wheat flour as a co-substrate, and undergoes composting process for 60 days inside horizontal rotary drum bioreactor. In addition, the inoculation of microorganisms likes *Phanerochaete chrysosporium*, *Trichoderma harzianum*, *Aspergillus niger*, *Penicillium sp* help to achieve good compost. The end product can be considered as good compost when several parameters like the C/N ratio, germination index and glucosamine assay met their standard. The C/N ratio range from 25 to 30, the germination index is up to 70% which is phyto toxic free and merely become mature compost.

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