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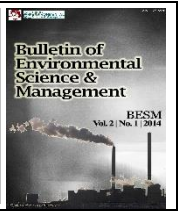

Mini Review: Environmental Benefits of Composting Organic Solid Waste by Organic Additives in Malaysia

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EM; Effective Microorganisms
IMO; Indigenous Microorganisms

Abstract

Solid waste generation has become one of the major problems throughout the world. Malaysia is no exception to this problem. An increasing generation of solid waste will lead to many problems in its management. Organic solid waste is a major contribution to solid waste in general. This paper discusses on how to manage organic solid waste, that is, the largest component in municipal solid waste generation in Malaysia. The composting process is seen as one of the best waste management options in managing the production of organic solid waste. Composting is the biological process that uses microorganisms, which transforms the organic solid waste into valuable products and turns the organic matters back to the soil under controlled conditions. Application of organic additives during composting can accelerate the process by using microorganisms to break down the organic matter in organic waste. The types of organic additives used are effective microorganisms and indigenous microorganisms. The environmental by-product of compost known as bio organic fertilizers could be a substitute of chemical fertilizers. The by-product of composting can be used in agriculture to increase soil stability and fertility.

INTRODUCTION

As the years go by, solid waste generation has become one of the major problems across the world, including Malaysia. This problem happens because of the increasing population growth, economy, development and urbanization of Malaysia. Table 1 shows the municipal solid waste generated in Peninsular Malaysia from 1998 to 2000 and generation of projection until 2020. This projection was based on the average generation rate of 21.4% from 1998 to 2000 [1].

From table 1, Selangor is seen to be the top generator of municipal solid waste with an estimate at 1,950,000 tonnes/ year and the lowest generator is Perlis with an estimate at 42,000 tonnes/ year. In 2010, Malaysia's population is 28.6 million and is projected to increase by 10 million (35.0%) to 38.6 million in 2040 [2]. This increase in population directly produces a large volume of solid waste. The local municipality was responsible in managing the solid waste generated in Malaysia.

The government and municipalities throughout the world is facing a major problem in managing solid waste [3]. Its management continues to be a major challenge in urban areas throughout the world, particularly in the rapidly growing cities and towns of the developing countries [4]. To ensure environmentally safe disposal of solid waste, the selection of the correct methods is required to treat waste by its types of generation [3]. These solid wastes are managed either by recycling, treatment and disposal at landfill as a final option for solid waste management.

Solid waste that has been generated should not be discharged without a suitable treatment. Proper treatment will prevent negative impact on the environment and allow the recovery of higher value added products. Increasing concerns about the negative impact of solid waste generation and discharge has led to research in the finding of a suitable treatment or management to treat solid waste properly. Improper management of solid waste can cause pollution to the environment. Various efforts have been made by the government to manage the solid waste that is generated day after day.

Municipal solid waste is suitable for composting because of the presence of a high percentage of biodegradable organic matter, acceptable moisture content and carbon: nitrogen ratio in the waste [5]. Organic solid waste is the major component of municipal solid waste being thrown in the landfill.

MUNICIPAL SOLID WASTE GENERATION

The problem related to the municipal solid waste becomes one of the issues in solid waste management since all of the waste is dispose directly in landfills. As the municipal solid waste increases, valuable plots of land have to be sacrificed as dumpsites [6]. Mostly municipal solid waste contains either waste that can be recycled or organic solid waste that can be decomposed itself. The decomposition of organic solid waste at landfill causes an environmental problem which also will affect human health.

During the decomposition of these organic materials that have been disposed in the landfill, several gases are released and chemical reaction will occurred. Organic solid waste at landfill will release toxic gases like nitrous oxide and high concentration of carbon dioxide. Methane gas produced by anaerobic biodegradation of municipal solid waste in landfill can cause fir and explosions.

Organic solid waste from landfill also produce unpleasant odor emission from the production of ammonia and hydrogen sulphide gases.

A major contributing factor to an increase of organic solid waste comes from human activities especially those from low income residential households. This is shown in Table 2, where the characterization of municipal solid waste by different levels of income of residents in Malaysia. Low income residential households show the highest percentage of organic and food waste production, since these residents tend to cook or prepared food at home. This is unlike residents with high and medium income who are more likely to buy or eat at restaurants. The types of organic solid waste contain of biodegradable organic materials that can decompose naturally in landfill [7].

The composting process is seen as the best method in overcoming the issues of increased organic solid waste being disposed directly in landfills and production of various gases. The purpose of composting is to stabilize the waste for land filling, reduce the volume and mass of solid waste and return the organic substances to their natural state. Currently in Malaysia, the composting process is recognized as the most adequate pre-treatment in order to obtain a composted material which may respond more efficiently and safely than the raw material to the soil [8].

COMPOSTING OF ORGANIC SOLID WASTE

Organic waste is a material that can be composted. It composts naturally while thrown in the land or during the composting process under controlled conditions. Not all solid waste can be composted. Organic kitchen and garden waste fall into the categories of organic waste that can be composted. Vegetables remains, fruit remains, potato peeling, egg shell, a tea bag and tissue are some example of organic kitchen waste that can be easily composted at home. The types of garden waste that can be composted are grass cutting, flower, leaves and roots. These types of organic waste mainly produced in residential area, restaurant, and institutional entities and cleansing playground.

Composting of organic solid waste is seen as an economical way in the treatment of waste. As mentioned before, composting helps reduce the volume of waste needed to be disposed at landfill. Composting can be defined as the process for the treatment of solid organic waste and the biological decomposition of raw compost materials to form compost [9]. Composting is also defined as a natural process that turns organic material into a dark rich substance called compost. During the composting process, microorganisms such as bacteria and fungi break down complex organic into compost. The compost is a wonderful conditioner for the soil [10].

COMPOSTING OF ORGANIC SOLID WASTE IN ADDITION OF ORGANIC ADDITIVES

The composting process occurs naturally but it takes a long time for the decomposition of organic materials to occur. Since the process is time consuming, it makes it unattractive for entrepreneurship prospect [11]. However, nowadays due to the advancements in composting technology like rapid composting using accelerators, co-composting using additives and microbial inoculums, entrepreneurs are likely to be attracted into the waste management sector.

Composting has been used widely in the treatment of various waste materials like animal waste, fish waste, sewage sludge, kitchen and garden waste and priority pollutants [12]. Various biological processes are used to decompose and humidify the complex organic matter in these materials including bulking agents (e.g., woodchips, sawdust, biochar) and some chemical additives are usually added to improve composting performance such as absorbing odor, adjusting the appropriate carbon-nitrogen (C/N ration), keeping the moisture content, total nitrogen, nutrients and enhancing the porosity and aeration [13].

Instead of using bulking agents with various biological processes in decomposition of organic matter, organic additives can be used in the composting of organic matter. Organic additives used in composting could produce an environmental product of compost known as bio organic fertilizers. Previous study has shown the effectiveness using effective microorganisms (EM) and indigenous microorganisms (IMO) during composting of organic solid waste. Beneficial microorganisms contained in EM and IMO accelerate the compost process under controlled condition besides producing final compost of high quality.

EM was developed from Japan and consists of mixed culture of beneficial microorganisms. It is a naturally occurring microorganism that can be cultivated through several methods. EM contains of acid lactic bacteria, yeast and a smaller number of photosynthetic bacteria, and other types of organisms [14]. Utilization of EM during composting has piqued the interest of researchers in the area of study.

Indigenous microorganisms are a clustered group of microorganisms that lives in a place. Local IMO can be cultivated through several methods, including the process of preparing IMO I until IMO IV. IMO is an organism that enriches the nutrient quality of soil. *Cynobacteria*, fungi and bacteria are the main sources of indigenous microorganisms [3].

Microorganisms like bacteria require carbon for energy and nitrogen for the production of amino acids and proteins in their bodies [15]. The combination used of EM and IMO with organic materials has been reported to quicken the decomposition process and mineralization of nutrients from applying organic amendments [14]. Although these two techniques using beneficial microorganisms play a role in breaking down organic matter during composting, but the methods and materials used in preparing these two additives are different due to their properties.

REVIEW OF COMPOSTING BY EFFECTIVE MICROORGANISMS

Effective microorganisms used as organic additives during composting process have received a lot of attention from researcher. Thus, various studies have been conducted using effective microorganisms to treat the solid waste and the product of compost was applied in plant growth. A previous study showed the application and effect of compost product on the rice productivity and quality of rice and greenhouse-grown tomato.

The effects of the integrated use of effective microorganisms, compost and mineral fertilizer on greenhouse-grown tomato was studied for the growth, yield and quality of tomato grown under controlled environment, with selected soil properties [16]. The result of this study is shown in Table 3. From Table 3, the application of effective microorganisms is seen to give negative effects on leaf dry matter yield, leaf number, number of trusses, fruit yield and fruits formed compared to the other treatment. However, the average fruit weight gives a positive result for application of effective microorganisms and the combine compost with effective microorganisms. It can be concluded that the more assimilates were being partitioned, the fewer fruits were formed.

Table 1. MSW generation by states in Peninsular Malaysia in thousand tonnes

State	1998	1999	2000	2010[a]	2015[a]	2020[a]
Kuala Lumpur	1058	1070	1082	1202	1262	1322
Selangor	1169	1204	1240	1595	1772.5	1950
Pahang	202	206	210	250	270	290
Kelantan	123	126	120	87	72	42
Terengganu	119	122	125	155	170	185
N. Sembilan	267	278	291	411	471	531
Melaka	208	216	225	310	352.5	395
Johor	927	956	1005	1395	1590	1785
Perlis	28	28	29	34	36.5	39
Kedah	569	569	631	941	1096	1251
Penang	611	611	648	833	925.5	1018
Perak	719	719	763	983	1093	1012
Total	6000	6105	6369	8196	9111	9820

a Projection based on (1998-2000) average increase rate of 21.4%.

Table 2. Typical Malaysia Municipal Solid Waste Characterization

Source	Residential high income (%)	Residential medium income (%)	Residential low income (%)
Food/Organic	30.84	38.42	54.04
Mix paper	9.75	7.22	6.37
News print	6.05	7.76	3.72
High grade paper	-	1.02	-
Corrugated paper	1.37	1.75	1.53
Plastic (rigid)	3.85	3.57	1.90
Plastic (film)	21.62	14.75	8.91
Plastic (foam)	0.74	1.72	0.85
Pampers	6.49	7.58	5.83
Textile	1.43	3.55	5.47
Rubber/leather	0.48	1.78	1.46
Wood	5.83	1.39	0.86
Yard	6.12	1.12	2.03
Glass (clear)	1.58	2.07	1.21
Glass (colour)	1.17	2.02	0.09
Ferrous	1.93	3.05	2.25
Non-ferrous	0.17	0.00	0.18
Aluminium	0.34	0.08	0.39
Batteries/hazards	0.22	0.18	-
Fine	-	0.71	2.66
Other organic	0.02	0.00	-
Other inorganic	-	0.27	0.25
Others	-	-	-

Table 3. Effects of EM, compost and mineral fertilizer combination on leaf dry matter yield (DMY), leaf number, number of trusses, fruit yield, fruits formed and on the average fruit mass of greenhouse-grown tomato.

Treatment	Leaf dry matter yield (g pot^{-1})	Leaf number/ g pot^{-1}	Number of trusses/ g pot^{-1}	Fruit yield (g pot^{-1})	Fruits formed/ pot^{-1}	Average fruit mass (g $fruit^{-1}$)
Control	45.8	21	11	418	15	42.1
EM	41.9	17	7	354.4	8	47.0
RF	57.3	39	16	563.4	20	29.8
EM + RF	53.2	34	15	526.6	17	31.0
Compost	48.7	20	9	470.0	10	51.5
Compost + EM	39.3	18	8	356.8	7	56.6
Compost + RF	70.0	32	15	632.8	20	32.7
Compost + RF + EM	59.7	33	13	555.1	20	29.1

EM: effective microorganism, RF: recommended fertilizer

A study of comparing the use of inorganic nitrogen fertilizer and EM-compost on paddy field fertility was done with a good result obtained by using EM-compost to enhance soil fertility and improve the growth of paddy [14]. EM-compost also increased the nitrogen and nutrients (N, P, K) in soil that more available for plant compared to chemical fertilizer. From the results shown, it can be concluded that utilization of EM-compost have many benefits towards rice quality that could help in control the use of nitrogen chemical fertilizers.

Application of effective microorganisms was also used in the composting of rice straw where an investigation of the composting of rice straw with EM and its influence compost quality was done [17]. Effective microorganism used during the composting process of rice straw with goat manure and green waste, consisting of two piles of treatment where one pile was applied with EM and another pile without EM. Decomposition of organic matter occurs in a 90 day period with tested parameters for temperature, pH, TOC, and carbon: nitrogen ratio. Macro and micronutrient content increases with application of EM during composting. The result also showed that compost applied with EM has more N, P and K content compared to the compost without EM.

Household and institutional entities are dominant in generating daily food waste. The effectiveness of using effective microorganisms in composting of kitchen waste was also widely studied. The results reveals that EM compost had a fast decomposition rate, more yield and richer in nutrients compared to natural compost [18]. Kitchen waste compost with EM produced no odor and the foul smell was more controlled during the composting process [3].

REVIEW OF COMPOSTING BY INDIGENOUS MICROORGANISMS

Utilization of indigenous microorganisms in composting process was not well documented by researchers. A study had been conducted to study the selection of indigenous microorganisms in enhancing IMO-compost production by using different indigenous microorganisms sources of compost quality [19]. It applied three different IMO sources which were steamed white rice (SWR), aerated fish pond water (AFPW) and kitchen waste (KW) for the final stages of cultivated indigenous microorganisms.

These three different sources of IMO were used to compost a paddy husk, corn stalk and adding a small portion of chicken dung as a nitrogen source. All of these IMO has attained an ambient temperature at 34 days of composting and indicate the stable nature of compost. In this study, IMO-compost using AFPW compost with corn stalk had shown the best sources for IMO to the local environment which give a high positive relationship of total N, P, K, carbon: nitrogen ratio, pH, TOC, OM and CEC with HA content. The impact of indigenous microorganism on soil microbial and enzyme activities also being studied [20] by comparing the soil treated with IMO and native sample. Physico-chemical properties for both soil shown that soil treated with IMO altered the physico-chemical than native. Physico-chemical properties tested were pH, water holding capacity, electrical conductivity, organic contents, phosphorus, potassium and carbon. Bacteria and fungi population also observed higher in soil treated with IMO than native soil. Soil treated with IMO has a relatively higher amount of proteases and urease enzyme compared to the native soil from this study.

As reported by the previous study about the advantages and benefits of using indigenous microorganisms and effective microorganisms in composting of various waste, organic solid waste is also suitable to be composted with the addition of organic additives. It can overcome the issue in managing of organic solid waste since the solid waste need not be disposed at the landfill.

ENVIRONMENTAL BENEFITS USING ORGANIC ADDITIVES IN COMPOSTING

The product of compost is usually used in agriculture as an organic fertilizer to improve the yield and crop and it can be used as a nutrient source for plant growth [21]. The final product of compost is also used as a soil conditioner to improve the soil structure, increase soil organic content and suppress plant pathogens.

Application of effective microorganism in the composting of rice straw, goat manure and green waste is suitable to increase the mineralization in the composting process and product of compost is in a range of mature level. The product of compost can be used without restriction [17]. The highest quality of compost produced and provide a better environment for the EM compost with kitchen waste has been determined [3]. EM compost also would reduce the use of chemical fertilizers and could be the best thing for a safer environment [14].

Organic composts additives used are materials that are environmental friendly to avoid any harm occur during or after the process of composting. A benefit of using organic additives in composting process is the absence of odor during the composting period. In addition, decomposition of organic material will take place in a shorter time with addition of organic additives. These organic additives are not a substitute for other management practices. EM and IMO only helps to enhance the number of fruits, promote plant growth and increase crop production. Its utilization and preparation do not involve any chemical that can harm the crops and yield. The addition of compost to the soil produces a general improvement of the soil characteristics both from physical and biological points of view [22].

The product of the final compost can be used as an organic fertilizer which is useful in the agriculture and this is one of the waste management options in solid waste. Compost can be used for vegetables gardens, flower gardens, lawn dressing and also house plant. Product of compost can be used to improve soil fertility and stability. It might be considered as a replacement for existing chemical fertilizers. An excessive use of chemical fertilizers and pesticides in agriculture can be a risk to human health. The product of compost must meet the criteria and standard that has been laid down by the government for the composting process to be considered successful.

CONCLUSION

Composting is seen as an environmentally acceptable method of waste treatment that not only reduces the environmental problems, [9] it also helps in reducing the amount of organic solid waste that is directly disposed at landfill, thus extending the life of the landfill. In addition, under controlled conditions it can minimize any harmful gases released during the decomposition process. Composting of organic solid waste as one of the waste management options can overcome the current issue of increasing production of organic solid waste. It is a simple process and can be easily applied at home on a smaller scale. Furthermore, the process to introduce and prepared organic additives such as indigenous microorganism or effective microorganism requires a minimal cost. Although composting is a simple and easy method that can easily be incorporated in any solid waste management, it is still not considered a major method in Malaysia. This is due to the lack of awareness among the community throughout the nation.

AUTHOR'S CONTRIBUTIONS

SNBK has designed and performed the manuscript framework and wrote this manuscript. IAZ has guided in the design of the manuscript and corrected the mistakes during the writing and preparation of the manuscript. TNTI has monitored the progress during manuscript preparation and give suggestion on manuscript submission. All the authors read and approved the final manuscript.

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REFERENCES

[1] Tarmudi, Z., M.L. Abdullah, and A.O.M. Tap, An Overview of Municipal Solid Waste Generation in Malaysia. Jurnal Teknologi, 2009. 51: p. 1-15.

[2] Population Projections Malaysia 2010-2040, November 2012, D.o.S. Malaysia, Editor. 2013: Kuala Lumpur.

[3] Sekeran, V., C. Balaji, and T.B. Pushpa, Technical Note: Evaluation of Effective Microorganism (EM) in Solid Waste Management. Electronic Green Journal, 2005. 1 (21): p. 1-5.

[4] Agamuthu, P., K. Khidzir, and M.S.H. Fauziah, Drivers of Sustainable Waste Management in Asia. Waste Management and Research, 2009. 27:625.

[5] Gautam, S.P., et al., Composting of Municipal Solid Waste of Jabalpur City. Global Journal of Environmental Research, 2010. 4 (1): p. 43-46.

[6] Senapati, B.K. and J.M. Julka, Selection of Suitable Vermicomposting Species under Indian Conditions. 1993.

[7] Kathirvale, S., et al., Energy Potential from Municipal Solid Waste in Malaysia. Renewable Energy, 2003. 29: p. 559-67.

[8] Kala, D.R., et al., Commercial Organic Fertilizers and Their Labeling in Malaysia. Malaysian Journal of Soil Science, 2011 15: p. 147-157.

[9] Yvette, B.G. and J.H. Robert, Composting of Organic Wastes: A Main Component for Successful Integrated Solid Waste Management in Philippine Cities. 2000.

[10] Tweib, S.A., R.A. Rahman, and M.S. Khalil, A Literature Review on the Composting, in International Conference on Environment and Industrial Innovation. 2012.

[11] J., et al., Additive Aided Composting Green Waste: Effects on Organic Matter Degradation, Compost Maturity and Quality of the Finished Compost. BioresourceTechnology, 2012. 114: p. 382-388.

[12] Zubillaga, M.S. and R.S. Lavado, Phytotoxicity of Biosolids Compost at Different Degress of Maturity Compared to Biosolid and Animal Manure. Compost Science & Utilization, 2006. 14: p. 267-270.

[13] Laos, F., et al., Composting of Fish Offal and Biosolids in Northwestern Patagonia. Bioresource Technology, 2002. 81: p. 179-186.

[14] El-Shafei, A., M. Yehia, and F. El-Naqib, Impact of Effective Microorganisms Compost on Soil Fertility and Rice Productivity and Quality. Misr J. Ag. Eng, 2008. 25 (3): p. 1067-1093.

[15] George, W.D., Description and Use of Municipal Solid Waste Composts in New Mexico. Extension Horticulture Specialist, 2010.

[16] Lindani, N. and M.O. Brutsch, Effects of the Integrated use of Effective Microorganisms Compost and Mineral Fertilizer on Grennhouse-Grown Tomato. African Journal of Plant Science, 2012. 6 (3): p. 120-124.

[17] Jusoh, M.L., L.A. Manaf, and P.A. Latif, Composting of Rice Straw with Effective Microorganism (EM) and its Influence on Compost Quality. Iranian Journal of Environmental Health Science & Engineering, 2013. 10 (17).

[18] Saravanan, P., S.S. Kumar, and C. Ajithan, Eco-friendly Practice of Utilization of Food Wastes, in International Journal of Pharmaceutical Sciences Innovation. 2013. p. 14-17.

[19] Hanim, A.N., et al. Selection of Indigenous Microorganisms in Enhancing Imo-Compost Production. in 11th International Annual Symposium on Sustainability Science and Management. 2012. UMT.

[20] Sumathi, T., et al., Impact of Indigenous Microorganisms on Soil Microbial Activity and Enzyme Activities. Archieves of Applied Science Research, 2012. 4 (2): p. 1065-1073.

[21] Farrel, M. and D.L.Jones, Critical Evaluation of Municipal Solid Waste Composting and Potential Compost Market. Bioresource Technology, 2009. 100: p. 4301-4310.

[22] Marinari, S., et al., Influence of Organic and Mineral Fertilizers on Soil Biological and Physical Properties. Bioresource Technology, 2002. 72: p. 9-17.