International Journal of Integrated Engineering: Special Issue 2018:
Innovations in Civil Engineering, Vol. 10 No. 9 (2018) p. 140-145

DOI: https://doi.org/10.30880/ijie.2018.10.09.026

Composting of Garden Waste using Indigenous Microorganisms (IMO) as Organic Additive

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Received 22 March 2018; accepted 11 December 2018, available online 31 December 2018

Abstract: Garden waste (GW) is considered as one of the types of municipal solid waste because of its biodegradable organic fraction. To avoid the disposal of green waste by open burning, incineration and landfill site, it can be manage by composting process. The objective of this study was to evaluate the performance of composting garden waste (dry leaves) by using indigenous microorganisms in term of the compost quality (pH, temperature, moisture content, C:N ratio and nutrient content). The compost has been prepared from three different mixtures of food waste for 30 days. IMO used as an organic additive during composting were prepared according to the method from previous study. The preparation of IMO consists of several phases include phase I until V with a mixture of various materials for each phase. During the composting process, all the parameters of IMO-compost obtained in a range like; pH value 8-9, temperature 30-48°C, moisture content 36-65%, nitrogen 2- 7%, phosphorus 4-8%, potassium 12-18% and C:N ratio 6-12. The result showed that all compost quality for IMO-compost obtained in an acceptable range for final compost to establish.

Keywords: Composting, green waste, indigenous microorganisms (IMO), compost quality

1. Introduction

All across the world, the management of solid waste generation is a major problem, which until now, it is still under major discussion globally [1]. Currently, it has become one of the most important environmental issues being discussed and Malaysia is no exception to this phenomenon. Garden waste (GW) is considered as one of the types of municipal solid waste because of its biodegradable organic fraction. Its generally consists tree trimmings, garden litter and trimmings, grass, leaves and other similar constituents [2].

During the dry season, the major component of GW is dry leaves. Traditionally, communities from the suburban and rural areas often openly burn these dry leaves that significantly can cause health problem, as it may contain hazardous chemicals from incomplete combustion. Besides that, another method to dispose of this GW waste was by deposited into landfill or incineration process. However, it is undesirable practices because it occupies valuable agricultural land, produced large amount of greenhouse gases and landfill sites are being filling up at a very fast rate [3,4].

According to the open burning, limited landfill and greenhouse gases issue, other options are needed to dispose these organic waste materials. The traditional methods like composting process is an environmentally acceptable way to dispose of garden waste [1,4,5]. However, about a months to years are required to generate mature compost from garden waste because of the lignin, cellulose and other polymers contain in green waste will inhibit biodegradation and slow down the decomposition process [1,6,7].

Composting process is seen as an environmentally acceptable method of waste treatment technology or in the handling of organic solid waste. It is an aerobic, biological process which uses naturally occurring microorganisms to transform biodegradable organic matter into a humus-like product [8]. The utilization of bulking agents usually used during composting process to improve the quality of compost produces. Sawdust, cotton waste, peanut shells and risk husks has been used in previous study as bulking agents during the composting of green waste [9].

An indigenous microorganism (IMO) is organisms that enrich the nutrient of soil quality and act as a reserve source for nutrient [10]. It contains beneficial microorganisms that play an important role in decomposition of organic matter. There is no previous study that has been conducted to compost garden waste with indigenous microorganisms. Thus, this study was conducted to evaluate the compost quality of IMO-compost by composting the garden waste (dry leaves) with indigenous microorganisms (IMO) as an organic additive.

2. Materials and Methods

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2.1 Indigenous Microorganisms (IMO) preparation

A small plastic container (0.19 × 0.26 × 0.01m) was filled with 200 g of rice and covered with white paper. Rubber bands were tied around the top of the container to secure the white paper in place. The box was then covered with a sheet of plastic to protect it from rain before placing it under the bamboo clumps to avoid direct sunlight. After 72 hours, the rice was covered with white mould (mycelium) and the smell was mildly sour. During this phase, indigenous microorganisms (IMO), IMO (I) were obtained.

A hundred grams of IMO I then was mixed with 0.1 kg of granulated brown sugar in the ratio of 1:1. This mixture was then placed in a plastic container in a cool spot for 5 days to allow the fermentation process to take place. After this period, the second phase of IMO II will begin.

Three grams of IMO II was then mixed with 3.0 kg of rice bran and 0.75 L of fermented rice wash water until the mixture appeared semi moist (about 65% moisture and temperature of not exceeding 70°C). A mound of mixture was placed above the sack and covered with 20 cm height of dried leaves to protect it from rain. The third phase of IMO III was produced after 5 days.

IMO III was mixed with soil based on the ratio of 1:1. About 1.0 kg of IMO III was mixed with 1.0 kg of soil and 0.25 L fermented rice wash water was added into this mixture. The mixture was kept at 65% moisture content and temperature not exceeding 70°C for a period of 5 days. The height of the mixture did not exceed 70 cm, and 20 cm height of dried leaves were used to cover the mound from rain. IMO IV was produced during this phase.

Based on a ratio of 10:1, 8.0 kg of dried goat dung were mixed with 0.8 kg of IMO IV. 2.0 L of fermented rice wash water was used to flush the mixture to maintain the moisture level of 65%. The daily temperature was maintained at a temperature not exceeding 70°C using a thermometer. After 14 days, the fifth phase produced IMO V and this was used as an additive during the composting process.

2.2 Collection of dry leaves and composting process

Garden waste (GW) which consisted of fallen and dry leaves was collected from the School of Environmental Engineering, UniMAP. GW was dried under the sunlight for 3 days and then pulverized to the size of 3 mm using a shredder machine. The purpose of shredding the GW was to increase the rate of the composting process

GW was analyzed for pH, moisture content and C:N ratio before composting process was performed. Dried chicken dung (CD) was used since it was difficult to obtain fresh chicken dung. The CD was mixed with GW and prepared IMO during the composting process as a source of nitrogen. The CD was obtained from a commercial chicken farm in Pauh, Perlis and it was characterized for pH, moisture content and C:N ratio before used.

The composting process was carried out in plastic bin containers (0.385 m height x 0.42 m width) and covered with aluminium foil to enable the absorption of heat from the sun. GW was the main materials in the composting process with the inclusion of IMO as additive and CD as a source of nitrogen based on a range of different ratios. Water was added in the course of mixing organic waste with IMO and CD to maintain the moisture content at 40-60%. The ratios used for GW composting were:

a) Ratio 1; 2:3:1 (2kg GW + 3kg IMO + 1kg CD)
b) Ratio 2; 3:2:1 (3kg GW + 2kg IMO + 1kg CD)
c) Ratio 3; 2:2:1 (2kg GW + 2kg IMO + 1kg CD)

The temperature was measured by using a thermometer and pH value was done by mixing sample into distilled water and stirred vigorously for 2 to 5 minutes and measured by using a pH meter. The moisture content was determined by drying the sample in an oven at 105°C for 24 hours. Total nitrogen was determined by using the CHONC Analyzer (Series II CHNS/O Analyzer 2400). The Fluorescent Spectrometer (XRF) (XRF-PANalytical) was used to measure the phosphorus and potassium content. The value of C:N ratio was calculated by dividing the value of total carbon to the value of total nitrogen.

3. Results and Discussion

In this study, no control was made. This is because the decomposition process of garden waste without any addition of bulking agents or additives will happen in a longer time. All of these mixtures treatment was characterized for pH, temperature, moisture content, total nitrogen, carbon to nitrogen ratio, phosphorus and potassium. IMO-compost of garden waste compost (GWC) matured after 60 days of composting period.

3.1 Effect of pH during composting process

Fig. 1. represents the changes in pH values of garden waste IMO-compost with the involvement of three different treatments from GWC1, GWC2 and GWC3. The pH value of the IMO-compost varied and fluctuated with time during the composting time. IMO-compost GWC2 showed a rise in pH value from 8.15 on day 3 to 9.03 on day 60.

The pH value for GWC1 increased from 8.25 on day 3 to 9.09 on day 12 and 9.07 on day 18. After that, the pH value increased again on day 33 at 9.05. Then, it decreased to 8.51 at the end of the composting time. IMO-compost GWC3 starting with pH 8.55 on day 3. The pH value showed a rise on day 12 with 9.10; 9.09 on day 30 and a pH of 9.06 on day 42. At the end of the process, the pH value decreased to 8.66 on day 60.

pH values are related to microbial activity and ammonia emissions, in which pH values obtained about or above 7.5 can cause a loss of nitrogen in the form of ammonia gas [11,12]. However, according to Sundberg et al. [13], the composting process was successful and fully developed at the pH values between 8.0 and 9.0. Microbial activities during the process produce ammonia during the ammonification and mineralization of organic nitrogen causes a rise in pH values for all the IMO-compost [14].

All the IMO-composts during this study were within the optimal pH range for the development of bacteria and fungi [15]. The function of these bacteria was to break down the complex organic waste to form humus or compost. These microorganisms also function in decomposition of organic matter and the production of organic and inorganic acids. Thus, it might also responsible for the decrease of pH [16].

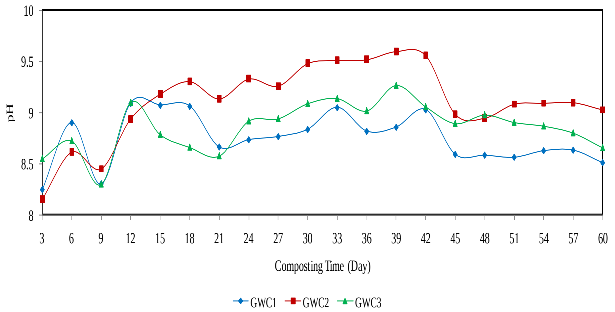

Fig. 1 The changes of pH over composting period

3.2 Effect of temperature during composting process

As shown in Fig. 2, IMO-compost treatments of GWC1 and GWC2 entered the thermophilic phase on day 12 and that lasted for 19 days with a range of temperature from 44°C to 42°C for both treatments. The GWC3 required a longer time to reach thermophilic phase starting on day 15 with 42°C until day 24 with 44°C. This indicated an increase in microbial activity occurring in the compost pile. IMO-compost GWC2 recorded the highest temperature during thermophilic phase, which was 48°C. The temperature was constant at 30°C starting from day 51 for GWC1, day 57 for GWC2 and day 54 for GWC3, respectively.

The population of microorganisms, through their respiration and decomposition of sugar, starch and protein, was responsible for heat generated during the composting process causing an increase of temperature from 42°C to 48°C [17]. In addition, the high rates of decomposition of organic matter lead to the rise in temperature [18]. The higher temperature denoted greater microbial activities, as the rise in temperature is related to microbial activities in the compost pile.

When the temperature of IMO-compost piles approached the cooling stage to an ambient level, the compost indicated a good degree of stability, in which all phases of temperature occurred during composting process [19]. The change from thermophilic to cooling stage causes a reduction in temperature. This situation occurred due to a decrease of oxygen, moisture content and easily decomposable organic matter in the IMO-compost pile which affected by the slowdown in microbial activities [18].

The temperature is considered ideal between 55°C to 65°C because at this temperature range, most weed seed and pathogens are killed [30]. However in this study, all IMO-compost treatments did not achieve that temperature although all piles reached thermophilic stages. This situation may have occurred due to low carbon to nitrogen ratio at the beginning of the composting process. Low carbon to nitrogen ratio will cause a scarcity of available carbon source and will have an effect on the growth and biological activity of microorganisms in the compost [18].

Almost all pathogens and seeds are killed at a higher temperature. According to Goyal et al., (2005) [21], the success of composting depends on the temperature reached during the process.

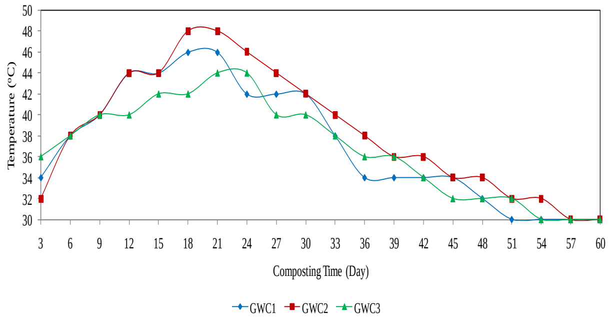

Fig. 2 The changes of temperature over composting period

3.3 Effect of moisture content during composting process

The moisture content of all the treatments throughout the composting process is indicated in Fig. 3. Usually, loss of moisture content during composting was caused by heat generated by the microorganisms. Moisture content is related to temperature, since moisture content will rise when temperature increases.

The highest moisture content was recorded on day 18 and 21 for IMO-compost GWC1 at 56.69% and 57.9%. IMO-compost GWC2 also recorded the highest moisture content on those days at 65.56% and 64.94%. For IMO-compost GWC3, the highest moisture content and temperature were respectively recorded on day 21 and day 24 at 61.12% and 55.6%.

As mentioned previously, moisture content is related to temperature. It affects microbial activity and the rate of decomposition process [22]. During the decomposition process, water loss through evaporation is smaller than water released through microbial activity. The higher temperature in the compost pile was caused by an increase in microbial activity. Thus, in this study, higher moisture content was recorded at high temperature.

Geroge [20], stated that the ideal moisture content should be maintained between 40% and 60% during the composting process. This rate of moisture content needs to support the growth of microorganisms that involved during the composting process. When the moisture content falls below 40%, the composting process may be inhibited and slowed down [12]. If the compost pile is too dry, it will become dusty and irrigating work.

IMO-compost treatment GWC2 showed the moisture content falling below 40% in the first 3 days during the composting process. However, the moisture content started to increase until the optimum moisture content was achieved in the range of 40% to 65% starting from day 6. The optimal moisture content for successful composting process varies depending on the physical state and size of the particles and depending on the methods used for composting.

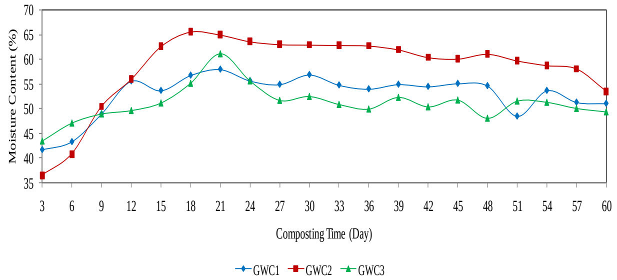

Fig. 3 The changes of moisture content over composting period

3.4. Effect of C:N ratio during composting process

Fig. 4 below demonstrates the trend of C:N ratio for four treatments of IMO-compost; GWC1, GWC2 and GWC3. The values of C:N ratio obtained during this study fluctuated and finally decreased at the end of the process for all treatments with an increase in composting time. The stabilization process and decomposition of organic matter were reflected by the changes in C:N ratio [23].

During the decomposition process, the carbon content of the compostable materials decreased with time because carbon is released as carbon dioxide. Meanwhile, the nitrogen content per unit increased. Thus, as composting proceed, the C:N ratio gradually decreases until the end of the composting period [28].

According to Jusoh et al. [7], a C:N ratio of less than 20 can be considered as mature compost, and it can be used widely without any restriction. The initial C:N ratio for all IMO-compost treatments in this study was in a range of 11-19. The value of the final compost was in a range of 6-12. IMO-compost GWC3 showed a poorer decomposition process because of a smaller decrease of C:N ratio at the end of the composting time [18].

Bernal et al. [15], discovered that a C:N ratio of less than 12 can be considered as stabilized. The stability stage is a condition at which the microbial activity at the end of the product is reduced to an insignificant level.

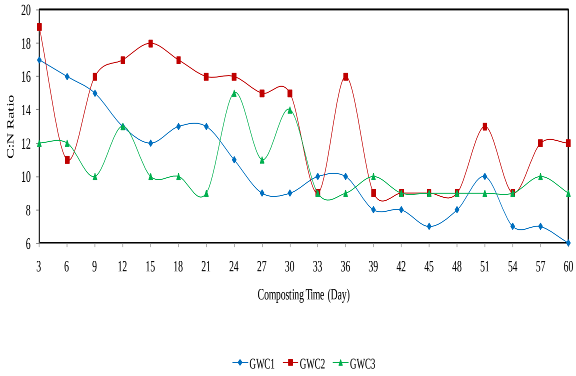

Fig. 4 The changes of C/N ratio over composting period

3.5. Effect of total nitrogen during composting process

The nitrogen content values started to increase until the end of the composting period over 60 days as shown in Fig. 5. The increment occurred due to the nitrogen fixing bacteria activity and the dry mass net loss as the loss of organic carbon as CO2 during composting [14,17].

Microorganisms present in the compost use nitrogen during the process to build up cells which caused the depletion in amount of nitrogen in the early stages of the composting process. During the process of building up cells, some of these organisms die and are recycled as nitrogen. Thus, this contributes to the increase of nitrogen content due to the stored source of nitrogen [17,25]. Besides, an increase in nitrogen content is caused by an increase in inorganic nitrogen because of the concentration effect as a consequence of strong degradation of organic carbon compound [26].

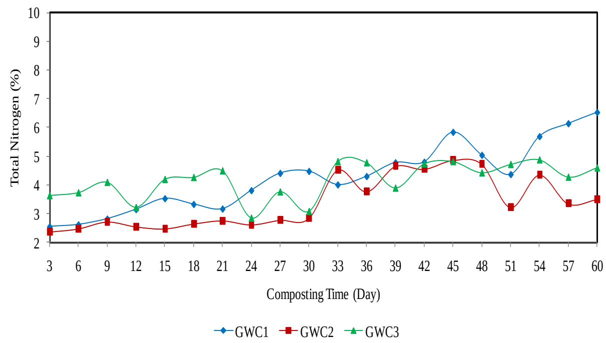

Fig. 5 The changes of total nitrogen over composting period

3.6. Effect of total phosphorus during composting process

Fig. 6 indicates the increase in total phosphorus content throughout the composting process. Lee [27] stated that the increases were caused by available phosphorus content in organic waste that was released through the mineralization process. Phosphorus solubilising microorganisms also contribute to the further release of this phosphorus content. Due to the richness of microbial populations in compost piles, the availability of phosphorus also increases [28].

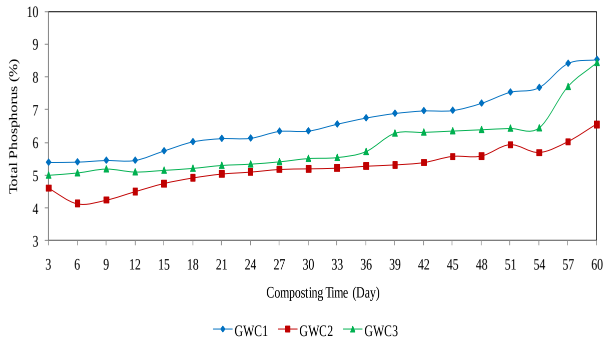

Fig. 6 The changes of total phosphorus over composting period

3.7. Effect of total potassium during composting process

Total potassium for all IMO-compost treatment of garden waste also increases during the decomposition process as illustrated in Fig. 7. The increase was due to the higher microbial activity in IMO-compost treatment which consequently caused a higher rate of mineralization [29].

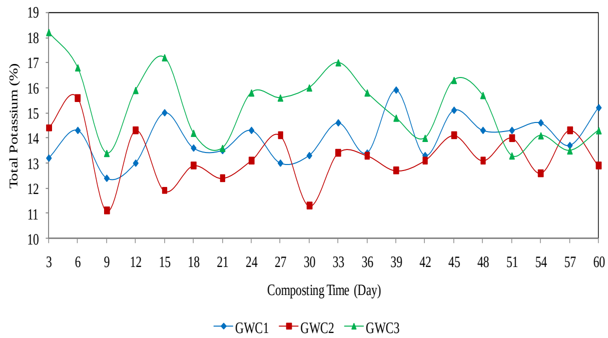

Fig. 7 The changes of total potassium over composting period

4. Summary

Composting of organic waste with IMO resulted in the maturity and stability of compost after 60 days for garden waste. The pH obtained during the composting process was in the range of 8.0 to 9.0 and the temperature recorded was in the range of 30 to 48°C. IMO-compost GW showed moisture content to be in the range of 36 to 65%. The NPK values for IMO-compost GW were in the range of 2 to 7%, 4 to 8% and 12 to 18%. The C:N ratios for all treatment of IMO-compost GW showed a value of 6 to 12.

The best ratios recommended to be used, based on this study during the composting process with three different ratios for each garden was IMO-compost GWC2. This is because, IMO-compost GWC2 recorded a respectively higher temperature of 48°C during the 60 days composting period. Besides that, the end C:N ratio of 12 recorded during the process was the highest among the other ratios.

The quality, stability and maturity of finished composts depended on the composition of raw materials used for compost production. Different organic waste and types of substrate used will give rise to different quality of finished compost, different characteristic and different potential markets.

References

[1] Zhang, L., Sun, X.Y., Tian, Y., and Gong, X.Q. Effects of brown sugar and calcium superphosphate on the secondary fermentation of green waste. *Bioresource. Technol*ogy, Volume 131, (2013), pp.68–75.

[2] Fernandez-Hernandez, A., Roig, A., Serramia,N., Civantos, C.G., and Sanchez-Monedero,M.A. Application of compost of two-phase olive mill waste on olive grove: Effects on soil, olive fruit and olive oil quality. *Waste Manage*ment, Volume 34, (2014), pp.1139-1147.

[3] Manaf, L. A., Samah, M. A. A., and Zukki, N. I. M. Municipal solid waste management in Malaysia: Practices and challenges. *Waste Management*, Volume 29, (2009), pp.2902-2906.

[4] Zhang, L., and Sun. X. Changes in physical, chemical and microbiological properties during the two-stage co-composting of green waste with spent mushroom compost and biochar. *Bioresource Technology*, Volume 171, (2014), pp.274-284.

[5] Caceres, R., Coromina, N., Malinska, K., Martinez-Farre, F.X., Lopez, M., Sava, M., and Marfa, O. Nitrification during extended co-composting of extreme mixtures of green waste and solid fraction of cattle slurry to obtain growing media. *Waste Management*, Volume 58, (2016), pp.118–125.

[6] Gabhane, J., William, S. P. M. P., Bidyadhar, R., Bhilawe, P., Anand, D., Vaidya, A. N., et al. Additive aided composting green waste: effects on organic matter degradation, compost maturity and quality of the finished compost. *Bioresource Technology*, Volume 114, (2012), pp.382-388.

[7] Karnchanawong, S., Mongkontep, T., and Praphunsri, K.,. Effect of green waste pretreatment by sodium hydroxide and biomass fly ash on composting process. *Journal Cleaner Production*, Volume 146, (2017), pp.14–19.

[8] Yvette, B. G., and Robert, J. H. Composting of organic aastes: A main component for successful integrated solid waste management in Philippine Cities. (2002).

[9] Zhou, H.B., Ma, C., Gao, D., Chen, T.B., Zheng, G.D., Chen, J., and Pan, T.H. Application of a recyclable plastic bulking agent for sewage sludge composting. *Bioresource. Technol*ogy. Volume 152 (2014), pp329–336.

[10] T. Sumathi, A. Janardhan, A. Srilakhmi, D.V.R. Gopal, D. and G. Narasimha,. Impact of Indigenous

Microorganisms on Soil Microbial Activity and Enzyme Activities. *Archieves of Applied Science Research 4,* Volume 2, (2012), pp.1065-1073.
[11] Mari, I., Ehaliotis, C., Kotsou, M., Chatzipavlidis, I., and Georgakakis, D. Use of sulfur to control pH in composts derived from olive processing by-products. *Compost Science & Utilization,* Volume 13, (2005), pp. 281-287.
[12] Tchobanoglous, G., Theisen, H., and Vigil, S. Intergrated Solid Waste Management. Engineering Principles and Management Issues. United States of America: McGraw Hill, (1993).
[13] Sundberg, C., Smars, S., and Jonsson, H. Low pH as an inibiting factor in the transformation from mesophilic to thermophilic phase in composting. *Bioresource Technology,* Volume 95, (2004), pp.145-150.
[14] Bishop, P. L., and Godfrey, C. Nitrogen transformation during sludge composting. *Biocycle,* Volume 24, (1993), pp.34-39.
[15] Hanim, A. N., Majid, M. N. M., Ahmed, O. H., and Khairulmazmi, K. S. A. *Selection of Indigenous Microorganisms in Enhancing Imo-Compost Production.* Paper presented at the 11th International Annual Symposium on Sustainability Science and Management, UMT, (2012).
[16] Huang, G. F., Wong, J. W. C., Wu, Q. T., and Nagar, B. B. Effect of C/N on composting of pig manure with sawdust. *Waste Management,* Volume 24(8), (2004), pp.805-813.
[17] Jusoh, M. L., Manaf, L. A., and Latif, P. A. Composting of rice straw with Effective Microorganism (EM) and its influence on compost quality. *Iranian Journal of Environmental Health Science & Engineering,* Volume 10 (17), (2013).
[18] Antil, R. S., Raj, D., Narwal, R. P., and Singh, J. P. Evaluation of maturity and stability parameters of composts prepared from organic wastes and their response to wheat. *Waste Biomass Valor,* Volume 4, (2013), pp.95-104.
[19] Satisha, G. C., and Devaranjan, L. Effect of amendments on windrow composting of sugar industry pressmud. *Waste Management,* Volume 27, (2007), pp.1083-1091.
[20] George, W. D. Description and use of municipal solid waste composts in New Mexico. *Extension Horticulture Specialist,* (2010).
[21] Goyal, S., Dhull, S. K., and Kapoor, K. K. Chemical and biological changes during composting of different organic wastes and assessment of compost maturity. *Bioresource Technology,* Volume 96, (2005), pp.1584-1591.
[22] Epstein, E. *The Science of Composting*. United State of America: CRC Press, (1997).
[23] Rashad, F. M., Saleh, W. D., and Moselhy, M. A. Bioconversion of rice straw and certain agro-industrial wastes to amendments for organic farming system: 1. composting, quality, stability and maturity indices. *Bioresource Technology,* Volume 101, (2010), pp.5952-5960.
[24] Bernal, M. P., Paredes, C., Sánchez-Monedero, M. A., and Cegarra, J. Maturity and stability parameters of composts prepared with a wide range of organic wastes. *Bioresource Technology,* Volume 63(1), (1998), pp.91-99.
[25] Palprasert, C. *Organic Waste Recycling. Technology and Management*. West Sussex, England: IWA Publishing, (1996).
[26] Tiquia, S. M., and Tam, N. F. Y. Fate of nitrogen during composting of chicken litter. *Environmetal Pollution,* Volume 110, (2000), pp.535-541.
[27] Lee, K. E. Some trends and opportunities in earthworm research or: Darwin’s children – the future of our discipline. *Soil Biology Biochemistry,* Volume 24, (1992), pp.1765-1771.
[28] Hait, S., and Tare, V. Transformation and availability of nutrients and heavy metals during integrated composting–vermicomposting of sewage sludges. *Ecotoxicology and Environmental Safety,* Volume 79, (2012), pp.214-224.
[29] Suthar, S. Vermicomposting potential of Perionyx sansibaricus (Perrier) in different waste materials. *Bioresource Technology,* Volume 98, (2007), pp.1231-1237.