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Research paper

Sewage Sludge and Municipal Solid Garbage Composting

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A R T I C l E I N F O

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A B S T R A C T

Co-compost could be gained by a mix of municipal solid garbage and sludge, that has been utilized in the agrarian grounds and solving municipal garbage and wastewater treatment plant issues. This investigation wants to present a method to set optimal situations like aeration speed, temperature, moisture range, C/N proportion, and particle size in composting procedure. Two pilots have been presented and in each pilot, various mixtures of municipal garbage, sludge, and wood pulp have been utilized. The size of the particle in mix and aeration speed were the distinctions between the 2 pilots. The outcomes demonstrated that the compost pile's pH has been almost ten in the start of the procedure and reduced to 7.25 slowly after seven days. The proper particle size has been 10 to 40 mm. The appropriate C/N proportion has been in the range of 25 and 35. It has been almost 33 in this experimentation. High temperatures lead to improving microbial movement in the start of the procedure. For homogenizing the temperature, it is essential for making an irritation of the compost pile each 4-6 days. An increase in co-compost temperature occurred while the moisture range has been from 50 to 60 percent. Aeration by 3 times of needed air has provided the best outcome. Ultimately, we have discovered that the moisture rate has more impact on microbial movement in comparison with the temperature. These outcomes support the utilization of the co-composting procedure by making up the size of particle and moisture abilities in preference to forced aeration-enclosed reactors.

Introduction

High product and accordingly high use is one of the features of the novel world. Compost is a natural procedure that microorganisms decay organic materials to easier nutrients. One of the fastest manner for producing high-grade compost, aerobic compost is a widely taken manner of stabilizing organic garbage and transforming them to a functional, and valuable counted compost production. Current wastewater treatment plants utilize a mix of biological, physical, and chemical procedures for treating wastewaters. A by-product of this treatment is bio solids, the dewatered sludge induced during preliminary, secondary, or developed treatment of municipal wastewater (Doubleta et al. 2010). Refining of sludge is very responsive and takes more cost in comparison with other parts in the wastewater treatment plants (Doubleta et al. 2010). For instance, 30 percent of the whole cost of manufacture in wastewater treatments plants is given to sludge fixing units (Eghball & Barbarick 2007, Asadi et al. 2012). Numerous searchers have performed research on the choice of the suitable way of sludge stabilization in some developed countries, and Iranian searchers must regard it too. Co-compost must be delivered and utilized in the appropriate and clean condition since the municipal garbage has irregular elements and the whole of its elements don't contain the capacity for decomposing and generating compost.

Furthermore, if some of the elements of the waste might have been blended in soil, the soil grade might have been reduced and it was contaminated with pathogens. These pathogens might have been cause some illnesses in animal and human. Furthermore, the sludge includes increased range of heavy metals, which can reduce the sludge grade (Alten & Edrin 2005). For neutralizing adverse impacts of garbage and sludge is transformation of these materials for composting and reutilizing them as organic fertilizer for farming (Kulikowska & Klimiuk 2010, Pandebesie & Rayuanti 2013). Raj & Antil (2012) performed 150 days of search work on compost product from farm garbage with agro-industrial garbage. Their outcomes indicate that neutral pH and a reduction in bacterial counts might be taken as a compost maturity index. Menaa et al. (2003) have studied on bioremediation of sewage sludge with composting. In investigation, a sewage sludge combined with wood shaving as bulking factor has been composted. In this procedure, a reduction of organic material particles according to organic material mineralization was seen. Fresh sewage sludge included pathogenic microorganisms' high number while this matter was presented to compost procedure, microorganisms reduced to appropriate level (Menaa et al. 2003).

Zorpasa et al. (2000) have accomplished a search on compost of municipal solid garbage, primary stabilized sewage sludge and natural zeolite (clinoptilolite). The last outcomes demonstrated that the composted matter created from clinoptilolite 20 percent and 80 percent sludge and MSW (60 and 40percent, orderly) delivered better soil condition compared to the compost created from sludge. Furthermore, the heavy metal concentration in the ultimate productions were in low concentration in comparison with the sewage sludge compost (Zorpasa et al. 2000).

Thus, the aim of this study is evaluating the relation among temperature, moisture range and microbial movement in bio solids compost. Quantify the impact of temperature and moisture range on microbial movement of a special mixture utilized in compost. Quantify of these connections would cause new intelligence toward good management of commercial bio solids compost. In most of the studies, which have been accomplished earlier, a factor or 2 have been seen in the experimentations while in this study, 3 factors like pH, moisture and temperature have been examined during the composition.

The scientific assistance in this study are gaining the optimal temperature for compost, gaining the optimal moisture range for compost and definition of the most suitable situations for a composting growing.

Methodology

In this study, the sludge, created from Yasreb wastewater treatment plant in Qaemshahr, has been utilized. Furthermore, the municipal solid garbage was gained from Anjelsi landfill in Babol. The size of particle in municipal solid garbage were 0 to 40 mm. The investigations have been accomplished in 2 sets in the various seasons. In the winter, first step was conducted by utilizing municipal garbage particles fewer than 10 mm and primary moisture about 78 percent by not considering irritation and various aeration speeds. In this investigation, the vertical plexiglass reactor by 20cm in diameter and 100cm in length has been utilized. For aerating the reactor, a vacuum engine by highest aeration power of 66 L/min has been utilized and it was established in bottom part of reactor. In addition, for circulation of air via co-compost has been utilized from wooden bulking factor of 5×5 cm in dimensions. For maintaining and controlling temperature in compost procedure, body reactor has been protected with glass wool.

Primary compost mix has been created from dehydrated sludge of wastewater treatment plant after second sedimentation, municipal solid garbage and bulk factor. For attaining optimal proportion, some samplings have been experimented. The wooden particles have been used as bulk factor according to higher moisture range and small dimension of channel matters (Doubleta et al. 2011). After sampling, the specimens have been maintained in cool situations until the investigation has been conducted. The investigations have been accomplished for measuring some grade possessions like dry solids, organic matters, C/N proportion ,and PH. The whole solids percentage in sludge has been estimated among 1 to 2 percent. Before loading, the sludge must be concentrated and dehydrated for achieving 30 percent concentrated solids. In first step, the sludge has been set in plastic receptacle for some hours and then divided into 2 dividable phase: water phase and dense solids, because the solids density in sludge gained to 2 to 3 percent. In next step, these matters were spread on a plastic in the land under the sun until the matters have been concentrated to 25 to 35percent. For producing dependable compost in lowest time, the compost procedure has been observed with sampling in appropriate time for measuring and adjusting of indicator elements of procedure like temperature, moisture range, and PH.

Procedure monitoring has been performed by sample and specification of the indicator characteristics range. Sampling has been conducted manually every 2 days. For determining the temperature and moisture range, the samplings have been delivered from the center and above the pile. One sampling has been delivered from this combination for determining the PH.

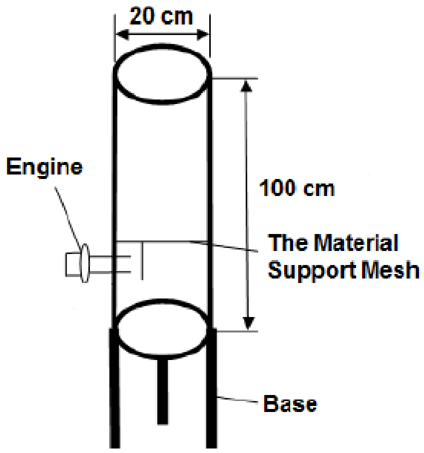

Fig. 1. Vertical pilot for co-compost schematics plot.

Specification of organic material and carbon

The combination proportion must be selected since it promotes modifying features of the procedure like strength, porosity, moisture range, and C/N proportion. Thus, the optimal C/N proportion for producing compost is 25:1 to 35:1 (Raja & Antil 2012, Srinivasan & Vijayalakshmi 2011).

In the combustion technique, 2 g of samplings have been considered and dried at 105°C for 24 hours in the oven (ASAE 2006). the dried sampling was considered for determining the dry weight (A). The dried sampling has been scorched at 550°C in a furnace.

by chilling in the desiccator, it has been weighed for measuring the weight of the ash (B). The organic materials' ranges and carbon have been estimated as following formulations: (APHA 2005).

$$Organic\ Material + \frac{[(A-B)\times 100]}{A}$$

$$Carbon = \frac{Organic\ Material}{1.8}$$

Nitrogen specification

The nitrogen range has been selected with Kjeldahl approach utilizing an automatic Kjeldahl analyzer (unit 2300). For nitrogen range specification, 0.5 g samplings have been spread to a particular investigation tube,10 mL of 0.1N H_2SO_4, a digestion shot including $CuSO_4$ or K_2SO_4, and some of them added octane normal as antiscam. The digestion technique was turned on formerly and after setting the pipes in the system, the furnace temperature has been increased to 400°C until the digestion fulfillment. After digestion and cooling, distilled water has been added to every pipe and set in the titration part of the automatic Kjeldahl analyzer. The samplings' titration has been accomplished for some minutes and the whole percent of nitrogen was registered on the monitor (APHA 2005, Keshavarz et al. 2012).

Moisture range, temperature, and pH specification

Following the compost pile loading for attaining the optimal function of the procedure, the procedure has been observed by calculating of indicator agents like pH, temperature, and percent of moisture range. The sampling moisture terminated from the compost pile has been estimated utilizing an oven-dry technique (Alten & Edrin 2005). two g of sampling (A) has been dried in an oven in 105°C for 24 h and a dried sampling has been weighed (B). The moisture range of sampling has been calculated as follows (APHA 2005):

$$Moisture\ Range = \frac{[(A-B)\times 100]}{A}$$

For determining the PH, ten g sampling has been weighed and poured into the Erlenmeyer flask and the next 100 mL of distilled water has been added to that. The set sampling has been located in an auto-shaker for thirty minutes (APHA 2005). The sampling PH has been calculated utilizing a PH meter. Temperature Measure is one of the most apparent factors in improving the fermentation procedure. Three thermocouple sensors have been utilized in the bottom, center, and the top level of the composting pile for measuring the temperature of the bulk. The amounts reported have been the mean of the matter temperatures calculated in the procedure in the 3 layers. Differences in the matter's temperature in the drying process have been registered to utilize a data logger.

Discussion and Results

The factors' impact like temperature, pH, and moisture range in the co-compost procedure has been studied in 2 phases.

First Phase

The C/N proportion in municipal solid garbage and sludge has been equivalent to 40:1 and 9:1, orderly. In this investigation, the municipal solid garbage mixture to sludge has been 3 to 1, and the C/N proportion has been 33:1. The differences in indicator agents like pH, temperature, moisture range, and aeration value in the experimentation are demonstrated in Figs. 2, 3, and 4. The deviation in the co-compost period PH over is demonstrated in Fig. 2. The compost pile PH has been 9.63 at the start of the procedure and afterward reduced to 7.15 slowly.

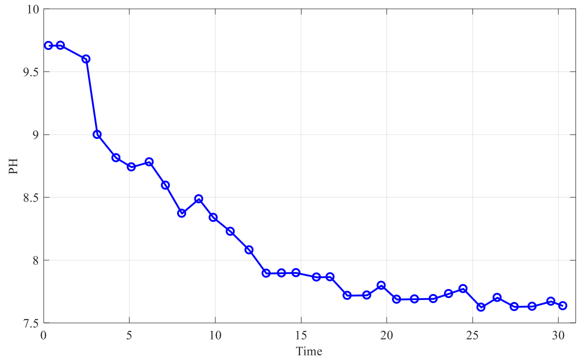

Fig. 2. PH amounts variation over time in first Phase.

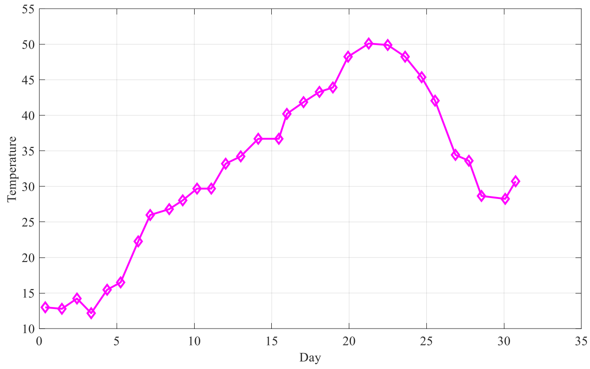

Fig. 3. Temperature variation over time in first Phase.

In some investigations, the temperature was demonstrated as a crucial composting performance determinant (Karak et al. 2013, Chai et al. 2013, Huang et al. 2004, Cronje et al. 2003). The changes in temperature for maintaining time are demonstrated in Fig. 3. It indicates that by a reduction in PH, the microbial movement has begun at the same time. In this study, PH has been obviously an essential agent affecting microbial movement in composting mixtures according to growth in temperature. Due to the cold temperature (8°C), the increment in temperature began on the 6-th day and advanced to 50°C after 25 days. Numerous researchers presented that the temperature limitation for optimum composting is among 52°C to 60°C (Guerra- Rodríguez et al. 2001, Oudart et al. 2012). Afterward this phase, the temperature dropped even the aeration has been stopped. In most circumstances, higher temperatures caused a sooner initiation of risen microbial movement.

Not increasing the temperature of compost means that the sludge doesn't possess ideal stability in the compost pile. This absence is associated with a reactor covering and cold climate. Furthermore, the number of matters and size of the reactor have influenced the temperature raising. A larger portion of matters and size of reactor delivers high temperature. The moisture range of the composting mixture is an essential environmental factor because it delivers a middle for the transportation of dissolved nutrients needed for the physiological movements of microorganisms (Evans & Furlong 2012, Raj & Antil 2012).

Fig. 4 illustrates the moisture change. According to this Fig, the moisture was reduced from the origin until the end of the procedure. According to the emulsion products, the moisture range decrease has been a little higher during the first week. After the rate of moisture range decrease has been reduced (Gigliotti et al. 2012). Extremely low moisture range amounts would generate premature dehydration in compost that would stop the biological procedure. Furthermore, high moisture might create anaerobic requirements from waterlogging that would stop the composting movements (Tang et al. 2003). The outcome demonstrates which an improvement in composting temperature has occurred while the moisture range was among 50 to 60 percent. The outcomes demonstrated the gained information before researchers (Tang et al. 2003, Kayikcioglu 2013, Liang et al. 2003) which 50-60 percent moisture range is appropriate for efficient composting.

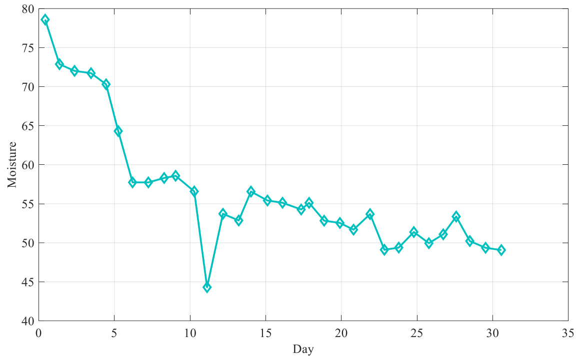

Fig. 4. Moisture variation over time in first Phase.

Second phase: Some factors have been changed to improve the fermentation performance in the second experimentation like the garbage particles size for simplifying aeration, nonoperation in primary days and then improving aeration speed. According to Fig. 5, gain in temperature speed has been desired. The temperature of compost has been reduced about 5°C after seven days according to starting of aeration. the temperature of the compost has been maintained at 55°C for 4 days.

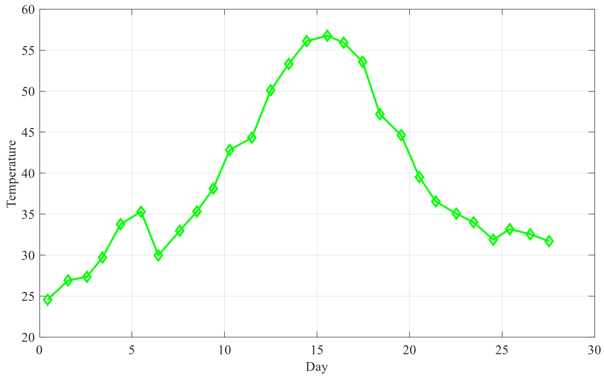

Fig. 5. Temperature variation over time in second Phase.

According to Fig. 6, the moisture amount has reduced with raising aeration speed and it has demonstrated for reducing the maintaining time for 4 days. The organic material decomposition for easier nutrients is natural procedure of microorganisms. Pathogens in compost have been connected to whole types of the microorganisms. These pathogenic organisms choose the temperature under 42°C. Researchers recommended that upper temperature could be appropriate for composting (Kayikcioglu 2013, Liang et al. 2003).

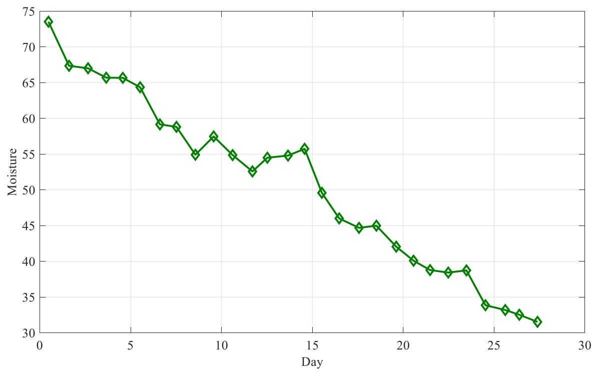

Fig. 6. Moisture variation over time in second Phase.

In compost procedure, some items are efficient on critical strategy of organisms like temperature, release of ammonia and period of procedure (Ogunwande et al. 2008). thorough of these factors, higher temperature in short period or lower temperature in long periods is so important for destroying pathogens in the composting pile (Ahn et al. 2007, Tchobanoglous et al. 2009). Thus, the most of pathogenic agents demonstrate in composting pile could be eliminated according to proper temperature because of the ultimate production would be voided of any pathogen (Ahn et al. 2007). Fig. 7 demonstrates the co-compost PH in the second experimentation. It is obvious that PH has a influential effect on composting efficiency (Yousefi et al. 2013). The compost pile PH has been of ten in start of the procedure and reduced to 7.25 slowly afterward seven days, and it was constant in the experimentation. The maintaining organic materials measuring environment sanitation stabilization sciences is interchangeable by the organic garbage oxidation and transforming them to a serviceable, non-dangerous and amount added matters. One of the measuring procedures of stabilization degree is according to calculating of maintaining organic matters in the procedure (Huang et al. 2004).

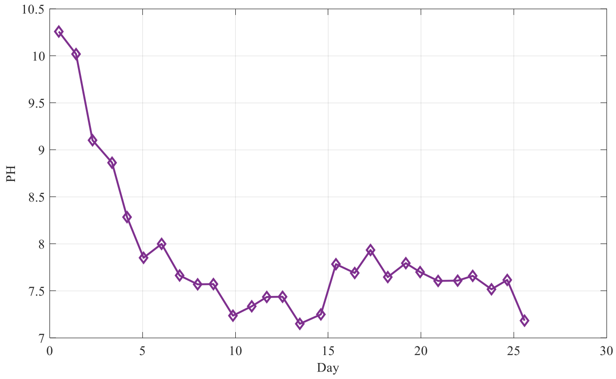

Fig. 6. PH variation over time in second Phase.

Deduction of organic materials is relies on mixture of matters and process in compost procedure. The organic materials could be stabilized in grown compost with measurement. Furthermore with estimating the remaining organic materials in compost from a group, thestabilization degree could be compared with each other quickly. The organic materials have been 30 percent in the first phase while they reduced to 25.4 percent in the second phase. It is deduced that the second phase composting is more developed (Gabhanea et al. 2012).

Conclusion

The aim of the investigation is developing a method to determine optimal situation like temperature, moisture range and C/N proportion in compost procedure. For increasing the connection surface to invasion of microorganisms, the size of particle should be little. The matters less than ten mm resulted in clod pile that forms an impermeable surface to pass the air to reduce moisture. The microorganisms can't feed from nutrients in the municipal solid garbage. Thus, the appropriate particles size is among 10 to 40 mm. The nitrogen is the major essential nutrient in microorganisms. The appropriate C/N proportion has been 25 to 35. With considering moisture priority in microorganisms, the appropriate moisture range has been 50 60 percent for sufficient compost. The aeration could reduce the composting moisture. Aeration with 3 times of needed air has been provided the most satisfactory outcome. For homogenizing and balancing the temperature, it is essential for making an agitating of the composting pile 4 to 6 days. The outcomes demonstrated that the composting pile's PH has been about ten at the start of the procedure and reduced to 7.25 slowly after of 7 days. The appropriate particle size has been 10 to 40 mm. The appropriate C/N proportion has been 25-35 and it was nearly 33 in experimentation. High temperature generated improving microbial movement at the starting of the procedure. Growing in temperature of co-compost has been occurred while the moisture range has been among 50-60 percent.

Ultimately, there is near relation among moisture range and temperature while the moisture range contains a more significant impact on the microbial movement of bio-solids combinations than does the temperature. The outcomes sustain the co-compost procedure utilization by size of particle and moisture abilities in priority to pushed aerated possessed reactors.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abdolkarim Keshavarz, Naser Mohammadian Roshan, Maral Moraditochaee, Ebrahim Azarpour and Ahmad Shirin Fekr 2012. Study effects of biological, manure and chemicals nitrogen fertilizer application under irrigation management in lentil farming on physiocochemical properties of soil. J. Basic. Appl. Sci. Res,. 2 (7). 6483-6487.

Ahn, H., Richard, T. and Glanville, T. 2007. Laboratory determination of compost physical parameters for modeling of airflow characteristics. Waste Manage., 32: 142-147.

Alten, A. and Edrin, E. 2005. Co-composting Solid Waste and Sludge of City Izmir. Die Festwoche der Abfallwirtschaft und Alt Lasten der TU Dresden, pp. 26-30.

APHA 2005. Standard Methods for the Examination of Water and Wastewater. 21st ed., American Public Health Association/ American Water Works Association/Water Pollution Control Federation, Washington DC., USA.

Asadi Ardali Hamed, Nazari Aslan and Nazari Hamed 2012. A survey of dry sludge from the activated sludge wastewater treatment plants in Iranian cold regions (A case study in Chaharmahal Va Bakhtiari Province). J. Basic Appl. Sci. Res., 2(11): 10869-10875.

ASAE 2006. Terminology and Definitions for Biomass Production, Harvesting and Collection, Storage Processing Conversion and Utilization Engineering Institute.

Chai, E., Hng, P., Peng, S., Wan-Azha, W., Chin, K., Chow, M. and Wong, W. 2013. Compost feedstock characteristics and ratio modelling for organic waste materials co-composting in Malaysia, Environmental Technology.

Cronje, A., Turner, C., Williams, A., Barker, A. and Guy, S. 2003. Composting under controlled conditions. Environmental Technology, 24(10): 1221-1234.

Doublet, J. B., Francou, C., Poitrenaud, M., Houot, S. 2011. Influence of bulking agents on organic matter evolution during sewage sludge composting; consequences on compost organic matter stability and N availability, Bioresource Technol., 102 (2): 1298-1307.

Doublet, J., Francou, B., Poitrenaud, M., Houot, S. 2010. Sewage sludge composting: Influence of initial mixtures on organic matter evolution and N availability in the final composts, Waste Manage., 30 (10): 1922-1930.

Eghball, B., Barbarick, K. 2007. Manure, Compost, and Biosolids, Encyclopedia of Soil Science, Second Edition. Ellina, S. Pandebesie, Dety Rayuanti, 2013. Rice Husk and Microorganisms Addition Increased Domestic Solid Waste Composting Process, J. Appl. Environ. Biol. Sci., 3(2): 13-17.

Evans, G., Furlong, J. 2010. Environmental Biotechnology: Theory and Application, Second Edition, 2010, Wiley publications.

Gabhane, J., William, S., Bidyadhar, R., Bhilawe, P., Anand, D., Vaidya, N., Wat, R. 2012. Additives aided composting of green waste: Effects on organic matter degradation, compost maturity, and quality of the finished compost, Bioresource Technol., 114: 382-388.

Gigliotti, G., Proietti, P., Pullicino, D., Nasini, L., Pezzolla, D., Rosati, L., Porceddu, P. 2012. Co-composting of olive husks with high moisture contents: Organic matter dynamics and compost quality, Int. Biodeter. Biodegr., 67: 8-14.

Guerra-Rodríguez, E., Vázquez, M., Diaz-Raviña, M. 2001. Dynamics of physicochemical and biological parameters during the cocomposting of chestnut burr/leaf litter with solid poultry manure, Journal of the Science of Food and Agriculture, 81, 7, 648-652.

Huang, G.F., Wong, C., Wu, T., Nager, B. 2004. Effect of C/N on Composting of Pig Manure with Sawdust, Waste Manage. 24: 805-813.

Karak, T., Bhattacharyya, P., Paul, R., Das, T., Saha, S. 2013. Evaluation of Composts from Agricultural Wastes with Fish Pond Sediment as Bulking Agent to Improve Compost Quality, CLEANSoil, Air, Water, 41, 7, 711-723.

Kayikcioglu, H. 2013. Effects of Composts from Agroindustrial Wastes on Microbial Activity of a Typic Xerofluvent Soil Under Mediterranean Conditions, SE Turkey, Geomicrobiology Journal, 30, 3, 228-236.

Kulikowska, D., Klimiuk, E. 2010. Co-composting of sewage sludge with lignocellulosic amendments assessment of compost quality, J. Biotechnol., 150, 282-283.

Liang, C., Das, K., Clendon, R. 2003. The influence of temperature and moisture contents regimes on the aerobic microbial activity of a biosolids composting blend. Bioresource Techno., 86:13,1- 7.

Mena, E., Garrido, A., Hernández, T., García, C. 2003. Bioremediation of Sewage Sludge by Composting, Commun. Soil Sci. Plan., 34 (7-8): 957-971.

Ogunwande, G., Osunade, A., Adekalu, K., Ogunjimi, L. 2008. Nitrogen loss in chicken litter compost as affected by carbon to nitrogen ratio and turning frequency. Bioresource Technol., 99: 7495-503.

Oudart, D., Paul, E., Robin, P., Paillat, J. 2012. Modeling organic matter stabilization during windrow composting of livestock effluents, Environmental Technology, 33, 9, 2235-2243.

Raj, Dev and Antil, R.S. 2011. Evaluation of maturity and stability parameters of composts prepared from agro-industrial wastes. Bioresource Technol., 102(3): 2868-2873.

Raj, D. and Antil, R.S. 2012. Evaluation of maturity and stability parameters of composts prepared from farm wastes, Archives of Agronomy and Soil Science, 58, 8, 817-832.

Antil, R.S. and Raj, Dev 2012. Chemical and microbiological parameters for the characterization of maturity of composts made from farm and agro-industrial wastes. Archives of Agronomy and Soil Science, 58(8): 833-845.

Srinivasan, T. and Vijayalakshmi, G. S. 2011. Biomanagement of banana leaf waste through microbial technology. J. Appl. Environ. Biol. Sci., 1(7): 126-128.

Tang, J., Inoue, Y., Yasuta, T., Yoshida, S. and Katayama, A. 2003. Chemical and microbial properties of various compost products. Soil Science and Plant Nutrition, 49(2): 273-280.

Tchobanoglous, G., Nemerow, N., Agardy, F., Sullivan, P. and Salvato, J. 2009. Environmental Engineering: Environmental Health and Safety for Municipal Infrastructure, Land Use and Planning and Industry. Sixth Edition, Wiley Publications. Yousefi, J., Younesi, H. and Ghasempoury, M. 2013. Co-composting of municipal solid waste with sawdust: Improving compost quality, CLEAN-Soil, Air, Water, 41(2): 185-194.

Zorpas, A., Evagelos Kapetanios, Giovanis A. Zorpas, Panagiotis Karlis, Apostolos Vlyssides, Ioanna Haralambous and Maria Loizidou 2000. Compost produced from organic fraction of municipal solid waste, primary stabilized sewage sludge and natural zeolite. J. Hazard. Mater., 77 (1-3): 149-159.