INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 12, No. 1, p. 330-337, 2018

RESEARCH PAPER OPEN ACCESS

Effect of waste physico-chemical properties on decomposition rates and nutrients release during composting

Mohammad Arshad[*1], Arshad Nawaz chaudhry[1], Ghulam Shaheer[1], Shakir Farroq[1], Shuja Manzoor[2], Ahsan Raza[1]

[1]*Department of Soil Science, Pir mehr Ali shah Arid Agriculture University, Rawalpindi, Pakistan*

[2]*Department of Agronomy, Pir mehr Ali shah Arid Agriculture University, Rawalpindi, Pakistan*

Key words: Composting, Organic waste, Maturity rates, Macronutrients

http://dx.doi.org/10.12692/ijb/12.1.330-337 Article published on January 30, 2017

Abstract

The stabilized and sanitized end product of composting is compost which is not only a source of macro and micro nutrients but also provides safe way for recycling of waste material and sustainable agriculture. The experiment was conducted at Pir Mehr Ali Shah Arid Agriculture University Rawalpindi. Pits were used for the preparation of compost. Farm yard manure (F.Y.M) and green manure organic waste material was used for the preparation of compost. Temporal nutrients changes in waste were monitored during composting process. Treatments were Farm yard manure (F.Y.M), Green manure, Farm yard manure (F.Y.M) + Green manure (WM) 1:1 by weight and Farm yard manure (F.Y.M) + Green manure (WM) 2:1 by weight. Higher temperature in thermophilic was observed in treatments T_4 (FYM + GM 2:1) and T_2 (FYM) temperature as compared to T_1 (GM) and T_3 (FYM + GM 1:1) which have green manure in high content. Maturity rate of different organic waste used in study and their macronutrients (N, P and K) status were as follow FYM > FYM+GM (2:1 W/W) > FYM+GM (1:1 W/W) > GM. It was concluded that farm yard decompose more rapid as compare to green waste and blending with green manure in an accurate content gives more stable and beneficial product.

[*] Corresponding Author: Mohammad Arshad ✉ arshadmustafa42@gmail.com

Introduction

Composting is naturally occurring waste recycling process for the reuse of essential nutrients present in organic materials which produced a stabilized and sanitized form of organic matter such as compost (Chaudhry *et al.,* 2013 and Khan *et al.,* 2003). Compost used in agricultural soils as an organic amendments and soil conditioner but it also economically beneficial for the humans as it overcome the contamination hazards of environment because it reduces the nutrient losses and to conserve soil (Nyamangara *et al.,* 2003).

It is expected that approximately 0.23 billion tons Nitrogen (N) produced annually from livestock manure worldwide in 2030 due to rapid development of intensive and industrialized livestock production (Davidson, 2012). Organic waste materials produced by city greenery have become a most important environmental problem in both developed and developing countries. In China, green waste (GW) is one of the main forest organic wastes only in Beijing approximately (50000–100000) tons of green waste produced per year (Zhang and Sun, 2016a).

Compost quality can be evaluated by parameters such as its stability and compost maturity. Application of immature and unstable form of compost to agricultural lands may reduce plant growth and yields by immobilization of nutrients in soil due to competition of oxygen in soil inhabiting microbe vs. roots and releasing toxic substances in root zone (Bernal *et al.,* 2009).

To handle this huge amount of organic waste produced and its safe and environment friendly disposal it is necessary to understand the composting process and issues concern with its stability and maturity as different studies demonstrated that much of the compost produced globally has different decomposition rate and maturity level depending on the nature of waste materials and also have different nutrients release pattern. The experiments were directed to find following objectives. I) find the best time of compost maturity during composting process by nutrient analysis at different intervals. ii) Check out the maturity levels of compost made up of various organic amendments.

Materials and methods

Study area

The experiment was conducted at PMAS-Arid Agriculture University Rawalpindi, Pakistan. Pits were used for the preparation of compost. Farm yard manure (F.Y.M) and Green manure organic waste materials were selected for the preparation of compost.

Treatments

Treatments were as follows, T_1= Farm yard manure (F.Y.M), T_2 = Green manure (G.M), T_3 = Farm yard manure (F.Y.M) + Green manure (WM) 1:1 W/W, T_4 = Farm yard manure (F.Y.M) + Green manure (WM) 2:1 by W/W.

Sampling

Sampling was performed systematically from each pit with three depths. Samples were taken after each fifteen days interval to analyze the following parameters such as moisture content, temperature, EC, Total organic carbon, Organic matter and Nitrogen , Phosphorus and Potassium.

Moisture Content

Gravimetric method was used to measure the moisture content (Gardner, 1986).

Temperature

Temperature reading was taken by using the thermometer. Temperature of the compost was measured by inserting thermometer at different depth of compost pit.

pH and EC

Compost pH was measured by 1: 5 W:V in 0.01mol L^{-1} $CaCl_2$ (suspension) while electrical conductivity were measured in water using compost water suspension 1:10 W:V (Andrade and Abreu, 2006).

Total Organic Carbon (TOC %)

Total Organic Carbon percentage in the ash was measured by combustion methods. Take 1g dried sample in crucible and place in muffle furnace at 550 (^{o} C) for 5 hours (Brake, 1992). Organic Carbon (%) = (100- ash %)/1.8 Factor (1.8) used to convert Ash % into TOC %.

Organic Matter of Compost

Total organic carbon that finds by combustion method was also used to determine organic matter (O.M %) of compost by using factor 1.724 which was used by (Nelson and Sommer, 1982) to convert TOC % into O.M %. O.M % = TOC × 1.724

Total Nitrogen

For total N, 1.0g dried compost sample was weighed into a micro Kjeldahl flask, then 20ml concentrated H_2SO_4 and 3.0g digestion mixture were added. Flask was heated until the digest was clear. Nitrogen was determined by distillation followed by titration against 0.01 N H2SO4 (Van Schouwenberg and Walinge, 1973).

Total phosphorus

Take 1 g sample in crucible and heat it into furnace at 550°c for 5 hours. After ashing, add 5ml 2N HCL and dilute to 50ml. Take filtrate using filter paper and store the filtrate in storage bottle for phosphorus and potassium determination. Take filtrate in 100ml volumetric flask and add 10ml color developing reagent Ammonium Heptamolybedate-ammonium vanadate solution. Measure the absorbance of light on spectrophotometer 430nm wavelength (Anderson and Ingram, 1993).

Total Potassium

Take a known amount of filtrate in volumetric flask and dilute to suitable range and measure the concentration of sample potassium on flame photometer (Wright and Stuczynski, 1996).

Statistical analysis

All obtained data was subjected to statistical analysis by using statisticx 8.1 tool and ANOVA was prepared using CRD and means were compared by least significance difference test at 95% significant level (Steel *et al.*, 1997).

Results and discussion

Moisture

Moisture in the composting piles maintained between (40-55 %) to process more efficiently.

Temperature

Maximum temperature (65.33°C) was recorded in T_4 (FYM +GM 2:1 w/w) and minimum (53.8°C) measured in T_1 (GM) at 60 day. Compost pile maintained the thermophillic temperature (>45°C) more than 30 days during thermophile stage (Fig. 1).

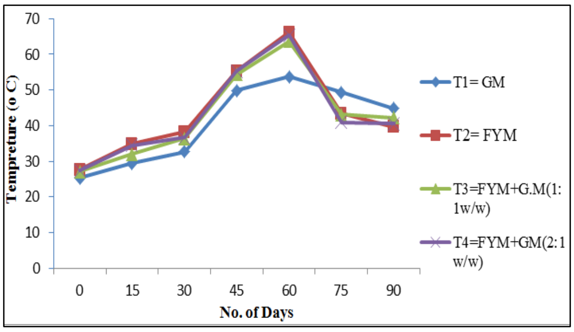

Fig. 1. Temporal Change in Temperature (°C) value during composting of different waste.

The more temperature in compost piles is due to summer season and also by the covering of composting pits with polythene sheet. Higher the temperature values in composting pits greater the activity of thermophilic bacteria and process complete more fast. Results are According to Zhang and Sun, (2014) which demonstrated that temperatures above 55°C in composting process favor for removal of most contaminants and materials was more stable and sanitized. As, thermophilic stage in composting occurring for more than three days all the harmful weeds, parasites and toxic compounds are eliminated from composting materials.

The results was also in similar with Moretti *et al.* (2015) which stated that the temperature value was decline when the composting process ended which is an indicators of maturity of materials, also aerate the pile of compost when temperature above 65°C. Results were also in agreement with Zang and Sun, (2016b) who recorded maximum temperature in thermophilic stage more than 65°C and also demonstrated that maximum temperature is the indicator of compost maturity and pathogen elimination. So it is cleared from literature that during composting more rises in temperature is good for production of quality compost.

pH

pH values was decline during the whole process of composting maximum value recorded at the end of composting process was measured in T_2 (7.17) and minimum in T_1 (6.23) (Fig. 2).

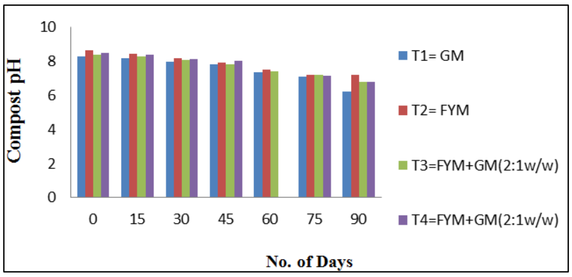

Fig. 2. Temporal Change in pH value during composting of different waste.

Results have similar trend with Moretti *et al.* (2015) who reported that a reduction in pH was observed in composting process a decrease of pH from (7.8–6.6) which indicates the significance of results. Ayesha *et al.* (2016b) also reported that the composting materials have pH in neutral near to 7 and a decrease in pH was recorded in her study. According to Huang *et al.* (2004) nitrification process increases with decrease in pH value of composted materials because it involves the production of organic acids and acidification the compost media.

Electrical conductivity

Maximum EC was measured in T_3 (1.7) which comprise of (FYM + GM 1:1 W/W) and minimum value (0.96) in T_4(FYM + GM 1:1 W/W) at the end of composting process after 90 days (Fig. 3).

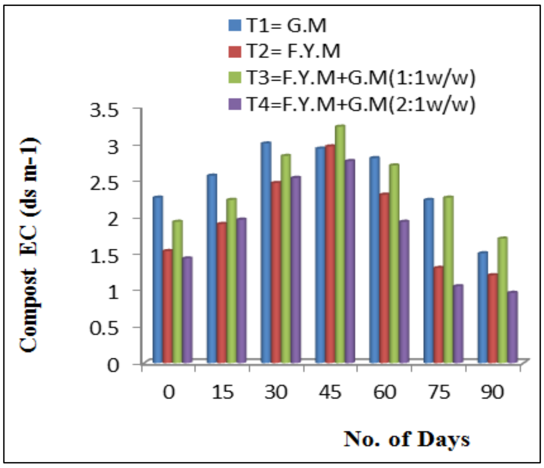

Fig. 3. Temporal Change in EC value during composting of different waste.

Low EC at the start of composting in organic waste is due to insoluble salts in organic matter as the process going on value rise due to breakdown of materials. In thermophilic stage it again decline because of maximum rate of decomposition and maximum microbial activity. More the activity of microbes more elements are used by microbes and salts becomes the parts of organics bodies. Results were in accordance to Moretti *et al.* (2015) who demonstrated that during his 120 days experiment (58%) reduction of EC was occur at the end of composting.

Result were in accordance to the finding of Bertoncini *et al.* (2008) which has the same trend of EC in composting of organic waste was measured. Decreases in electrical conductivity value at the end of composting processes were also due to the leaching of compost leachate as we irrigate the composting materials.

Toc %

Total organic carbon percentage decline in all four treatment during whole process of composting and maximum value was measured at the end after 90 days in T1 (17.22%) and minimum in T2 (14.62%) (Fig. 4).

Results are in agreement with Asim *et al.* (2015) which observed a relation between Carbon value and the stability of the composted materials. Results shows that a Carbon value less than twenty was good for composted materials but a value of 15 or below 15 considered more appreciable. According to Zhang and Sun, (2016b) green waste have slow rate of degradation due to the presence of ligno-cellulose which resistance to degradation which were according to our data that shows green waste mature at slower rate in about 90 days.

It was concluded that green waste mature at slow rate as compare to farm yard the reason of low maturity was due to the presence of lingo cellulose compounds and also it can't attain higher temperature in thermophilic stage. The control of moisture in green waste was also difficult as it dries more rapidly which was also a reason of its slower rate of decomposition.

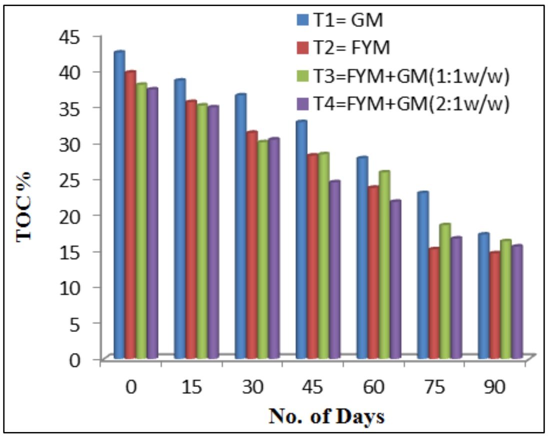

Fig. 4. Temporal Change in TOC % value during composting of different waste.

Organic matter %

Organic matter percentage decline during composting process and maximum value of organic matter measured after 90 days in T1 (29.68 %) and minimum in T2 (25.21%) (Fig. 5).

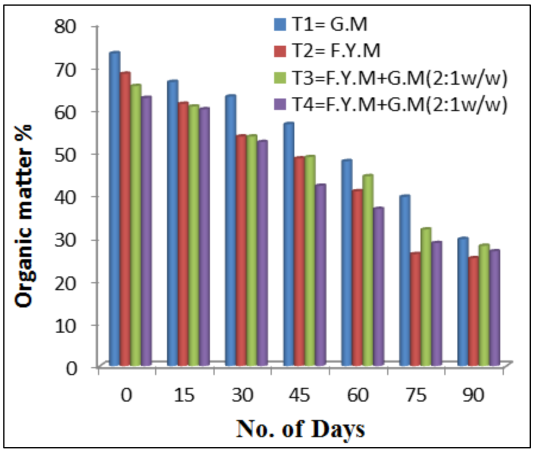

Fig. 5. Temporal Change in O.M % value during composting of different waste.

Less the O.M content in final product was the indication of more stable compost. It also described the maturity level of different organic waste as FYM decompose more easily as compare to green manure due to the presence lingo-cellulose in green manure which resistance to degradation and decompose at slower rate. Results were in agreement to Ayesha *et al.* (2016a), who observed O.M % less than 30 is the indication of maximum degradation and production of mature compost. Result was also in according the Grigatti *et al.* (2004) which stated that O.M % must be below 30 after completion of composting.

Macronutrients (N, P and K)

Maximum value of total nitrogen, total phosphorus and total potassium were measured in T_4 (3.41%, 1.12% and 2.62%) and minimum in T_1 (2.43%, 0.82% and 2.31 %) respectively as showed in Table 1 through 2, 3).

Nitrogen

Results were in familiar with Kapanen, (2001) which finds the maximum concentration of nitrogen at the end of composting process. Results were also in agreement with Fabio *et al.* (2015) which determined total nitrogen in several waste on monthly basis and find the maximum amount at the end of composting process. According to Hogarh *et al.* (2008) that Nitrogen content of compost used in agricultural soil has a range between 3 to 4 (%) as the compost comprise of mostly farm yard manure which are rich in Nutrients (macro nutrients).

It was proved that blending of farm yard manure with green manure in an adequate amount gives higher amount of total nitrogen in the composting process at the end, T_4 was the best treatment.

Total phosphorus

Increase in phosphorus content with the passage of time was due to microbial degradation and availability of more nutrients. Results were similar with Zibliske, (1987) which demonstrated that composted dairy manure had higher amount of phosphorus after composting due to volume reduction. Results were also in agreement with Chaudhry *et al.* (2013) who found higher value of (N, P and K) during his experiment on composted manure. Results were also in line with Asim *et al.* (2015) which studied the nutrients release pattern of organic waste and found maximum macronutrients in composted materials at end of process. Similar results were also observed with the findings of Preusch *et al.* (2002).

Table 1. nitrogen % at different days.

Treatments	0	15	30	45	60	75	90
T_1	0.63d	0.70c	0.97d	1.27d	1.77d	2.11d	2.43d
T_2	0.78b	0.99b	1.49b	1.97b	2.73b	3.27b	3.29b
T_3	0.69c	0.95b	1.41c	1.77c	2.52c	3.12c	3.22c
T_4	0.83a	1.05a	1.53a	2.13a	2.77a	3.40a	3.41a
LSD	0.03	0.04	0.03	0.03	0.03	0.03	0.03

Table 2. phosphorous % at different days.

Treatments	0	15	30	45	60	75	90
T_1	0.43c	0.47c	0.51c	0.56c	0.70c	0.76d	0.82d
T_2	0.58a	0.64a	0.68a	0.73a	0.85b	0.97b	0.98b
T_3	0.49b	0.55b	0.59b	0.65b	0.72c	0.81c	0.89c
T_4	0.58a	0.63a	0.68a	0.74a	0.79a	1.11a	1.12a
LSD	0.03	0.02	0.03	0.03	0.02	0.04	0.04

Table 3. potassium % at different day during composting**.**

Treatments	0	15	30	45	60	75	90
T_1	0.44b	0.62c	0.82b	1.17c	1.84c	2.05d	2.31c
T_2	0.71a	0.86a	1.02a	1.39a	2.04a	2.47b	2.48b
T_3	0.66a	0.82b	1.00a	1.28b	1.79b	2.38c	2.47b
T_4	0.66a	0.82b	1.00a	1.34a	2.01a	2.61a	2.62a
LSD	0.05	0.03	0.06	0.05	0.04	0.05	0.04

Rodriguez *et al.* (2001) stated that an increase in the potassium concentration during composting and co-composting and results shows that when waste materials was decomposed in adequate amount of blending gives more nutrients at the end which is according to our results. Higher the amount of potassium in composted materials was due to the process of mineralization and a decrease in content was due to fixation or immobilization. Clark, (2000) observed that the amount of potassium increased in organic waste from start to end due to the microbial decomposition of manure.

Conclusion

It was concluded that farm yard manure decompose more rapidly due to more microbial attack as compared to green manure. As the decomposition rate of farm yard manure was high the mineralization of organic matter is also high which was directly proportional to nutrients release in process and rapid maturity of waste materials.

References

Anderson JM, Ingram JSI. 1993. Colorimetric determination of nitrogen and phosphorus. Tropical soil Bio and fertility. A handbook of methods. International p. 73-74.

Andrade JC, Abreu MF. 2006. Chemical analysis of solid waste for monitoring and agri-environmental studies. In: Andrade, J. C., A. A. Falcao, M. F. Abreu, (Eds.) Protocols for chemical analysis. p. 121-158. Instituto Agronômico, Campinas, SP Brazil.

Asim H, Chaudhary AN, Hussaina F, Iqbal T, Suthara V, Jalilc SU, Ali Z. 2015. Nutrients Dynamics of Co-composting Poultry Litter with Fast Food Wastes. Pakistan Journal of science and biology **58(2),** 77-82.

Ayesha A, Jalil A, Raza S. 2016a. Determination of total organic matter of mature compost prepared by using municipal solid waste. International Journal of Science and Research Publication **6(5),** 293-295.

Ayesha A, Jalil A, Raza S. 2016b. Effect of pH and moisture content on composting of Municipal solid waste. International Journal of Science and Research Publication **6(5),** 35-37.

Bernal MP, Albuquereque JA, Moral R. 2009. "Composting of animal manures and chemical criteria for compost maturity assessment: a review". Bioresourse Technology **99,** 3372- 3380.

Bertoncini EI, Dorazio, V, Senesi N, Mattiazzo ME. 2008. Effects of sewage sludge amendment on the properties of two Brazilians oxisols and their humic acids. Bioresourse Technology **99,** 4972-4979.

Brake JD. 1992. A practical guide for composting poultry litter. MAFES Bulletin 981, june, 1992. Department of poultry science, Mississippi state university USA.

Chapman HD, Pratt PF. 1961. Methods of Analysis for soils, plants and water. University of California, Berkely, CA USA.

Chaudhry AN, Naeem MA, Jilani G, Razzaq A, Zhang D, Azeem M, Ahmed M. 2013. Influence of composting and poultry litter storage methods on mineralization and nutrient dynamics. Journal of Animal and Plant science **23,** 500-506.

Clark S. 2000. Development of a Biologically Integrated Food Waste Composting System. Berea College, Kentucky USA.

Cooperband LR, Stone AG, Fryda MR, Ravet JL. 2003. Relating compost measures of stability and maturity to plant growth. Compost Science & Utilization **11(2),** 113-124.

Davidson EA. 2012. Representative concentration pathways and mitigation scenarios for nitrous oxide. Environmental Research Letters **7(2),** 24005-24011.

Fabio T, Pagliaro G, Giovanni PD, Floriani E, Mangani F. 2015. Biowaste home composting: Experimental process monitoring and quality control. Waste Management **38,** 7285.

Fleming MY, Tai P, Zhuang MB, McBride. 2013. Extractability and bioavailability of Pb and As in historically contaminated orchard soil: effects of compost amendments. Environmental Pollution **177,** 90-97.

Gardner WH. 1986. Physical and Mineralogical Methods. Methods of Soil Analysis. Part 1. ASA. No. 9. Madison, Wisconsin, USA p. 383-411.

Gonzales HB, Sakashita H, Nakano Y, Nishijima W, Okada M. 2010. Food waste mineralization and accumulation in biological solubilizationand composting processes. Chemosphere **79,** 238-241.

Grigatti M, Ciavatta C, Gessa C. 2004. Evolution of organic matter from sewage sludge and garden trimming during composting. Bioresource Technology **91(2),** 163-169.

Hogarh JN, Fobil JN, Budu GK, Carbo D, Ankrah NA, Nyarko A. 2008. Assessment of Heavy Metal Contamination and Macro-nutrient Content of Composts for Environmental Pollution Control in Ghana. Environmental Research **2,** 133-139.

Hortaa C, Marta R, P. Joao C, Antonio CD, Jose T, Andrew S. 2017. Organic amendments as a source of phosphorus: agronomic and environmental impact of different animal manures applied to an acid soil. Archive Agronomy. Soil Science **63(5),** 673-679.

Huang GF, Wong JWC, Wu QT, Nagar BB. 2004. Effect of C/ N on composting of pig manure with sawdust. Waste Management **24,** 805-813.

Kapanen G. 2012. Pool of mobile and immobile phosphorus in sediments of the large, shallow Lake Peipsi over the last 100 years. Environmental Monitoring and Assessment **184**, 6749-6763.

Karak T, Bhattacharyya P, Paul RK, Das T, Saha SK. 2013. Evaluation of composts from agricultural wastes with fish pond sediment as bulking agent to improve compost quality. Clean-Soil, Air, Water **41,** 711-723.

Khan MA, Rahim M, Ali S. 2003. Sewage sludge effect on soil fertility of maize as compared to poultry litter, farmyard manure and chemical fertilizer. Pakistan Journal of Agricultural Sciences **6,** 69-77.

Moretti SML, Bertoncini EJ, Abreu-Junior CH. 2015. Composting sewage sludge with green waste from tree pruning. Journal of agricultural science **72(5),** 341-347.

Nelson DW, Sommers LE. 1982. Total carbon, organic carbon and organic matter. In: A. L. page, R. H. Miller and D.R. Keeney (Eds), methods of soil analysis, part 2, Agron. Monogr. 9. ASA and ASSA, Madison WI p. 539-594.

Nyamangara J, Bergstorm LF, Piha MI, K. Giller KE. 2003. Fertilizer use efficiency and nitrate leaching in tropical sandy soil. Journal of Environmental Quality **32,** 599-606.

Preusch PL, Adler PR, Sikora LJ, Tworkoski TJ. 2002. Nitrogen and phosphorus availability in composted and uncomposted poultry litter. Journal of Environ. Qual **31,** 2051-2077.

Rodriguez GE, Vazquezand M, Ravina MD. 2001. Co-composting of Chestnut burr and leaf litter with solid poultry manure. Bioresourse Technology **78,** 107-109.

Steel RGD, Torrie JH, Dickey D. 1997. Principle and Procedures of Statistics A biometrical Approach. McGraw hill Book Co., New York 633 pp.

Van Schouwenberg JCH, Walinge I. 1973. Methods of analysis for plant material. Agriculture University Wageningen, The Netherlands.

Wright RJ, Stuczynski TI. 1996. Atomic Absorption and Flame Emission Spectrometry. In: D. L. Sparks, (Eds). Methods of Soil Analysis. Part-III: Chemical Methods. SSSA, Madison 65-90.

Zhang L, Sun X. 2014. Changes in physical, chemical, and microbiological properties during the two-stage co-composting of green waste with spent mushroom compost and biochar. Bioresours Technology **171,** 274-284.

Zhang L, Sun XY. 2016a. Improving green waste composting by addition of sugarcane bagasse and exhausted grape marc. Bioresourse Technology **218,** 335-343.

Zhang L, Sun XY. 2016b. Influence of bulking agents on physical, chemical, and microbiological properties during the two-stage composting of green waste. Waste Management **48,** 115-126.

Zibilske LM. 1987. Dynamics of nitrogen and carbon in soil during paper mill sludge decomposition. Soil Science **143,** 26-33.