Asian Journal of Water, Environment and Pollution, Vol. 15, No. 1 (2018), pp. 87–91.
DOI 10.3233/AJW-180009

An Investigation on the Optimum Composition of Suitable Co-composting Material for the Enhancement of the Soil Organic Carbon in Mango Orchards of Pollachi, Tamil Nadu

N. Natarajan*, K.R. Sabadini, R. Shunmuga Priya, A. Anbarasan and V. Sankar
Department of Civil Engineering, Dr. Mahalingam College of Engineering and Technology
Pollachi – 642003, Tamil Nadu, India
✉ itsrajan2002@yahoo.co.in

Received April 29, 2017; revised and accepted December 8, 2017

Abstract: Soil organic carbon is an important component of the soil. Environmental pollution is increasing day by day leading to significant rise of carbon content in the atmosphere. Growing crops with manure having high soil organic carbon content can facilitate in the reduction of carbon content in the air and subsequent alleviation of environmental pollution. Hoping to fulfill the above objective, this study is aimed at determining the optimum content of suitable co-composting material for the enhancement of soil organic carbon of soil collected from a mango agricultural field. Natural materials, viz. tissue paper, paper ash, wooden powder, egg shells and organic waste matter have been used as co-composting materials. Soil organic carbon content was measured for various combinations of co-composted soil with natural soil. The results of the study suggest that wood ash proves to be a suitable co-composting material for increasing the soil organic carbon content of soil upto 125,847 kg C/ha for a combination of 40% organic co-composted soil and 60% wood ash co-composted soil.

Key words: Soil organic carbon, co-composting, biodegradable materials, organic matter, wood ash.

Introduction

Carbon dioxide is a greenhouse gas which traps the heat in the atmosphere. The absence of greenhouse gases would make living on earth unaffordable but the CO_2 content has increased by significantly in the air today due to rapid urbanisation and industrialisation. This has resulted in global warming and melting of ice caps. Therefore, it is important to reduce the carbon content in the atmosphere. A vast majority of this carbon is added to the soil every year.

Soil carbon is present is two forms, namely, inorganic and organic. Soil organic carbon is the largest terrestrial carbon pool and plays an important role in the global carbon cycle (Batjes, 1996; Bohn, 1982; Grace, 2004; Lal, 2004). Soil organic carbon is closely related to soil quality, nutrient availability, and crop yield (Gal et al., 2007). Decomposition of soil organic carbon can increase the CO_2 levels (Wiesmeier et al., 2014) and its sequestration can significantly reduce the climate change effect (Zhao et al., 2015). Thus, increasing the soil organic carbon content has two major benefits – mitigating climate change and improving the soil fertility.

*Corresponding Author

There are many soil management practices for increasing the soil organic carbon. In this study, an attempt has been made to increase the soil organic carbon by enriching the existing soil with co-composted soil. Composting is a natural process that turns organic material into a dark rich substance called compost. Composting has received increasing attention as an environmentally acceptable way to dispose of and utilize organic wastes (Zhang and Sun, 2014). Raut et al. (2008) have reported that composting helps in managing large quantities of organic wastes in a sustainable manner and recycles organic materials into useful products. Composts derived from organic wastes have recently been proved to have better quality than commercial inorganic fertilizers (Chowdhury et al., 2015). The humic-like fraction of composts improves plant growth and health and also exerts biocontrol on different soil-borne phytopathogens such as fungi (Traversa et al., 2010). Temperature build-up during composting has resulted in elimination of pathogenic organisms in waste (Pandey et al., 2016). Mohammad et al. (2012) acknowledged the contribution of compost in improving the water-holding capacity of soil.

Thus, it is observed from the literature that composting plays a major role in increasing the organic content of the soil. As far as the authors' knowledge is concerned, the optimum content of the co-composted material that needs to be augmented to increase the soil organic carbon content of the soil has not been studied. In this study, composted soil was prepared using different biodegradable materials such as tissue paper, egg shells, wood ash, paper ash, etc. The soil organic carbon content was determined for both natural soil as well as co-composted soil and the most suitable co-composted material was assessed. Then, the optimum content of this co-composted material was analysed by conducting studies on various combinations of co-composted material and organic matter.

Methodology

The red loamy soil sample was taken from the mango vegetation field since it is assumed to possess high soil organic carbon. The Anaimalai region in Pollachi from where the soil sample was collected is shown in Figure 1.The geographical co-ordinates of this location is 10° 35′ 0″ North and 76° 56′ 0″ East.

Figure 1: Anaimalai region in Pollachi from where soil sample was collected.

The soil sample was taken at the four corners of the vegetation field at a depth of 0.3m. The dimensions of soil sampling were 20 cm × 20 cm. The soil collected at the four corners was thoroughly mixed and a total mass of 2 kg was taken. This natural soil was cleaned and dried. A portion of this natural soil was composted using various biodegradable materials. This soil was composted using organic matter (vegetable and fruits debris), tissue paper, paper ash, paper soaked in water, wooden powder and egg shells separately. Eleven different combinations of soil samples were prepared for testing, namely natural soil composted with organic matter, natural soil composted with tissue paper, combination of tissue paper composted soil and organic co-composted soil, natural soil composted with paper ash, combination of paper ash composted soil and organic co-composted soil, natural soil composted with paper soaked in water, combination of paper soaked in water composted soil and organic co-composted soil, natural soil composted with wooden powder, combination of wooden powder composted soil and organic co-composted soil, natural soil composted with egg shell, combination of egg shell composted soil and organic co-composted soil. The soil organic carbon content was estimated using the Walkley and Black (1934) method. The following reagents were used in this study:

1. 1 N potassium dichromate: 49.04 gm AR grade $K_2Cr_2O_7$ (dry) was dissolved in distilled water to make a volume of one litre.
2. Concentrated sulphuric acid (Sp. Gravity 1.84, 96%): If the soil contains chloride, 1.25% silver sulphate may be added in H_2SO_4.
3. Ortho phosphoric acid (Sp. Gravity 1.75, 85%)
4. Diphenyl amine indicator
5. 0.5 N Ferrous ammonium sulphate –196.0 g of AR grade ferrous ammonium sulphate was dissolved in distilled water, 20 ml of concentrated H_2SO_4 was added to make a volume to one litre.

The percentage of soil organic carbon was calculated using the following expression:

% of organic carbon = Volume of 1N $K_2Cr_2O_7$ – [Volume of 1N $K_2Cr_2O_7$*(Sulphate used for sample titration/Sulphate used for blank titration)]*0.003*200

In the above expression 0.003 is used to convert 1 ml of 1N $K_2Cr_2O_7$ into grams of carbon and 200 is used to convert the organic carbon content obtained for 0.5 g to that of 100 g of soil.

Results and Discussion

The working principle used in this method is that organic carbon is oxidized with potassium dichromate in the presence of concentrated sulphuric acid. Potassium dichromate produces nascent oxygen, which combines with the carbon of organic matter to produce CO_2. The excess volume of $K_2Cr_2O_7$ is titrated against the standard solution of ferrous ammonium sulphate in presence of H_3PO_4, using ferroin to detect the first appearance of unoxidised ferrous iron and thus volume of $K_2Cr_2O_7$ can be found out which is actually required to oxidize organic carbon.

The soil organic carbon content was calculated based on the titration studies. The percentage of soil organic carbon obtained in 11 different soil samples is shown in Table 1.

Table 1: Percentage of carbon content in different soil samples

Compost sample	*Carbon (%)*
Soil before composting	0.736
Organic co-composted soil	**1.415**
Tissue paper	0.736
Tissue paper + Organic co-composted soil	1.302
Paper ash	0.792
Paper ash + Organic co-composted soil	1.132
Paper soaked in water	0.792
Paper soaked in water + Organic co-composted soil	1.189
Wooden powder	**1.525**
Wooden powder + Organic co-composted soil	1.358
Egg shell	0.849
Egg shell + Organic co-composted soil	1.075

It is observed from Table 1 that the natural soil co-composted with wooden powder showed the maximum soil organic carbon content of 1.525% followed by soil co-composted using organic matter with 1.415%. It is also interesting to note that only wooden powder co-composted soil has resulted in such a high soil organic carbon percentage without the addition of organic co-composted soil. All other materials that were used for composting resulted in soil organic carbon content more than 1% only when organic co-composted soil was added to them. The carbon content calculated in terms of kg C/ha is shown in Figure 2.

It is observed from the figure that the soil organic carbon content of wooden powder co-composted soil is about 114,407 kg C/ha and the organic matter co-

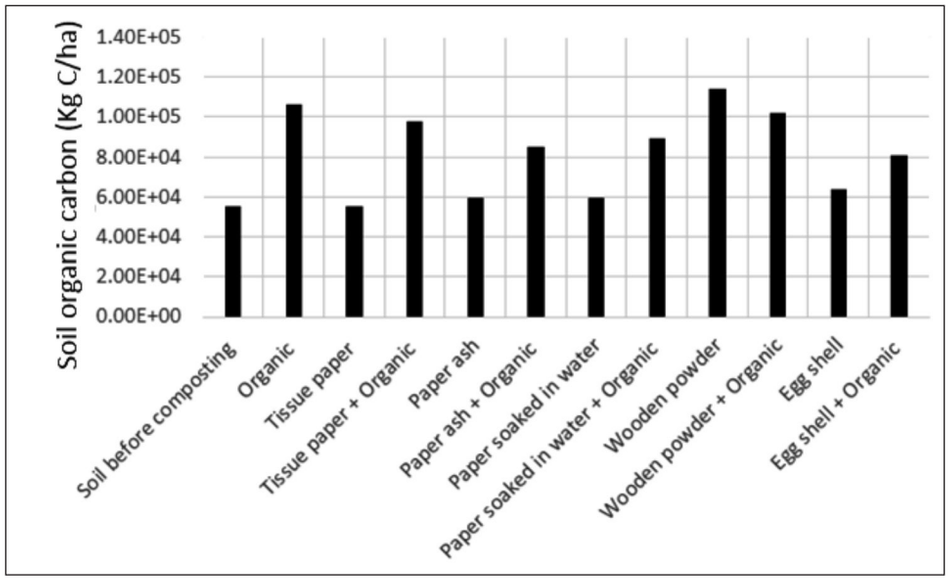

Figure 2: Soil organic carbon content for different soil samples in terms of kg C/ha.

composted soil has resulted in 106,125 kg C/ha. Thus wooden powder has a good potential for improving the soil organic carbon content. This can be used along with organic matter in improving the carbon content of the soil. This will facilitate the growth of the plants tremendously and in turn play a role in reducing the carbon content in the atmosphere. Consequently, environmental pollution can be reduced to a large extent.

Since organic co-composted soil and wooden ash co-composted soil has provided high soil organic carbon content, different combinations of these two soil types were considered for determining the soil organic carbon content. The ratio of combinations considered for this study has been provided in Table 2.

Soil organic carbon content was determined for the different combinations shown in Table 2 using Walkley and Black method. The result of the test performed is illustrated in Figure 3.

From Figure 3, it is observed that the soil organic carbon content reaches a maximum value of 125,847 kg C/ha for a combination of 40% organic co-composted soil and 60% wooden ash co-composted soil.Thus, it can be concluded that a 40% organic co-composted soil and 60% wooden ash co-composted soil is the optimum combination for obtaining high soil organic carbon content for red loamy soils used for the mango orchards.

Table 2: Ratio of combination of organic co-composted soil and wooden ash co-composted soil

Sl. No.	*% of organic co-composted soil (a)*	*% of wooden ash co-composted soil (b)*
1	5	95
2	10	90
3	15	85
4	20	80
5	25	75
6	30	70
7	35	65
8	40	60
9	45	55
10	50	50
11	55	45
12	60	40
13	65	35
14	70	30
15	75	25
16	80	20
17	85	15
18	90	10
19	95	5

Conclusion

The natural soil was co-composted using materials like egg shell, tissue paper, wooden powder, water soaked paper and paper ash. Soil samples were prepared using organic co-composted soil and soil co-composted using other natural materials. The soil organic carbon content was determined for the 11 soil samples. Wooden powder co-composted soil was found to have a very high organic carbon content followed by organic matter

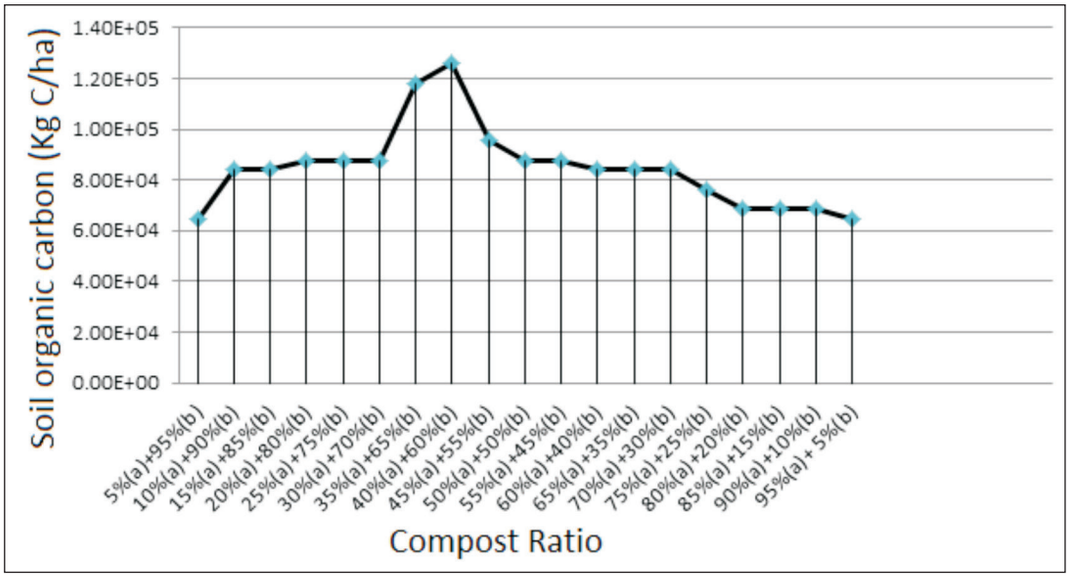

Figure 3: Soil organic carbon content for different proportions of (a) organic co-composted soil and (b) wooden ash co-composed soil.

co-composted soil. Wooden powder can be a potential material for increasing the carbon content of natural soil and thus enhance the production of crops. A maximum value of soil organic carbon content of 125,847 kg C/ha was obtained for a combination of 40% organic co-composted soil and 60% wooden ash co-composted soil.

References

Batjes, N.H. (1996).Total carbon and nitrogen in the soils of the world. *Eur. J. Soil Sci.*, **47:** 151–163.

Bohn, H.L. (1982). Estimate of organic carbon in world soils: II. *Soil Sci. Soc Am. J.*, **46:** 1118–1119.

Chowdhury, A.K.M.M.B., Konstantinou, F., Damati, A., Akratos, C.S., Vlastos, D., Tekerlekopoulou, A.G. and D.V. Voyenas (2015). Is physicochemical evaluation enough to characterize olive mill waste compost as soil amendment? The case of genotoxicity and cytotoxicity evaluation. *J. Clean. Prod.*, **93:** 94–102.

Gal, A., Vyn, T.J., Micheli, E., Kladivko, E.J. and W.W. McFee (2007). Soil carbon and nitrogen accumulation with long-term no-till versus moldboard plowing overestimated with tilled-zone sampling depths. *Soil Tillage Res.*, **96:** 42–51.

Grace, J. (2004). Understanding and managing the global carbon cycle. *J. Ecol.*, **92:** 189–202.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma*, **123:** 1–22.

Mohammad, M., Alam, M., Kabbashi, N.A. and A. Ahsan (2012). Effective composting of oil palm industrial waste by filamentous fungi, a review. *Resour. Conserv. Recycl.*, **58:** 69–78.

Pandey, P.K., Cao, W., Biswas, S. and V. Vaddella (2016). A new closed loop heating system for composting of green and food wastes. *J. Clean. Prod.*, **133:** 1252–1259.

Raut, M.P., William, S.M.P.P., Bhattacharyya, J.K., Chakrabarti, T. and S. Devotta (2008). Microbial dynamics and enzyme activities during rapid composting of municipal solid waste compost maturity analysis perspective. *Bioresour. Technol.*, **99:** 6512–6519.

Traversa, A., Loffredo, E., Gattullo, C.E. and N. Senesi (2010). Water-extractable organic matter of different composts, A comparative study of properties and allelochemical effects on horticultural plants. *Geoderma*, **156:** 287–292.

Wiesmeier, M., Hübner, R., Spörlein, P., Geub, U., Hangen, E., Reischl, A., Schilling, B., Lützow, M. and I. Kögel-Knabner (2014). Carbon sequestration potential of soils in southeast Germany derived from stable soil organic carbon saturation. *Glob. Chang. Biol.*, **20:** 653–665.

Zhao, M.S., Zhang, G.L., Wu, Y.J., Li, D.C. and Y.J. Zhao (2015). Driving forces of soil organic matter change in Jiangsu Province of China. *Soil Use Management*, **31:** 440–449.

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

CAPITAL PUBLISHING COMPANY

Recent and Forthcoming Publications on Climate Change and Environmental Sciences

Mohanty	Advanced Numerical Modeling and Data Assimilation Techniques for Tropical Cyclone Predictions
Goel	Advances in Soil and Hazardous Waste Management
Rakhecha	Applied Hydrometeorology
Nagarajan	Climate and Natural Resources
Subramanian	Coastal Environments — Focus on Asian Regions
Nagarajan	Drought Assessment
Křeček	Ecosystem Services of Headwater Catchments
Ramesh	Fresh Water Management
Naqvi	Geology and Evolution of the Indian Plate (From Hadean to Holocene – 4 GA to 4 KA)
Sharma	Geology of Andaman - Nicobar: The Neogene
Basavaiah	Geomagnetism: Solid Earth and Upper Atmosphere Perspectives
Thakur	Geospatial Techniques for Managing Environmental Resources
Raju	Geostatistical and Geospatial Approaches for the Characterization of Natural Resources in the Environment: Challenges, Processes and Strategies
Mitra	Global Environmental Changes in South Asia: A Regional Perspective
Sikdar	Groundwater Development and Management: Issues and Challenges in South Asia
Thangarajan	Groundwater Flow and Mass Transport Modeling
Ghosh	Groundwater Governance
Ghosh	Groundwater Modelling and Management
Thangarajan	Groundwater: Resource Evaluation, Augmentation, Contamination, Restoration, Modeling and Management
Ray	High Impact Weather Events over the SAARC Region
Machiwal	Hydrologic Time Series: Theory and Practice
Beheim	Integrated Watershed Management
Chatterjee	Macro-Economics of Mineral and Water Resources—Important Issues
Ramanathan	Management and Sustainable Development of Coastal Zone Environments
Krecek	Management of Mountain Watersheds
Raju	Management of Natural Resources in a Changing Environment
Raju	Management of Water, Energy and Bio-Resources in the Era of Climate Change: Emerging Issues and Challenges
Das	Microbial Fuel Cell: A bioelectrochemical system that converts Waste to Watts
Kayal	Microearthquake Seismology and Seismotectonics of India
Talapatra	Modelling and Geochemical Exploration of Mineral Deposits
Mohanty	Monitoring and Prediction of Tropical Cyclones in the Indian Ocean and Climate Change
Jha	Natural and Anthropogenic Disasters: Vulnerability, Preparedness and Mitigation
Nagarajan	Natural and Mad-made Disasters: Assessment and Management
Subramanian	Rivers of South Asia
Ramanathan	Safe and Sustainable Use of Arsenic Contaminated Aquifers in the Gangetic Plain: A Multi-Disciplinary Approach
Behari	Sustainability, Green Energy and Climate Change: Revisited
Datta	Theory and Principles of Simulation Modelling in Soil-Plant System
Kurisu	Trends in Asian Water Environmental Science and Technology
Mohapatra	Tropical Cyclone Activity over the North Indian Ocean
Nagarajan	Water: Conservation, Use and Management for Semi-arid Regions

For more detailed information on individual titles, please log on to our website www.capital-publishing.com