JOURNAL OF AGRICULTURE AND BASIC SCIENCES
ISSN Online: 2518-4210
http://www.jabsjournal.com/

Full Length Research Article

Mineralization of carbon from composted and raw organic wastes and its consequences on environment

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Abstract

For measurement of the rate of organic matter decomposition, carbon dioxide evolution is a good indicator and it also helps to evaluate the nutrient release pattern and optimal time for the organic material application. In the current study, mineralization rates of the N-enriched compost and un-composted fruit and vegetable waste along with equal quantity of N as in enhanced compost were assessed by exploration of carbon dioxide evolution under laboratory conditions. Accumulative CO_2 evolved from diverse treatments was also determined. The study showed that CO_2 discharge from N-enriched compost-amended soils was considerably slower than that documented in fresh organic waste and fresh organic waste along with urea-enriched material observed in standardized homogeneous conditions. The material modified with fresh (un-composted) organic waste exhibited extra accumulative CO_2 evolution than that documented in case of raw organic waste plus urea and urea-enriched composted organic waste. This study results suggest that the composted organic wastes had more constancy over un-composted organic waste which may possibly be useful towards sustainable agriculture and environment.

Key Words: CO_2 evolution, organic matter, composting, C: N ratio

Introduction

Soil organic matter (SOM) content and its mineralization are closely associated to soil fertility and availability of nutrients (Zechand and Kogl-Kanaber, 1996). The SOM plays colossal role in universal C cycle, equally in helping as group in requisitioning C and besides as a fluctuation in discharging C. Soil organic carbon (SOC) pool are adversely affected by land use, crop and soil management. Failures in SOC pool are owing to (i) mineralization of the organic carbon in the soil, (ii) transportation through erosion of the soil, (iii) percolating underside the soil or to the underground water body (Sparks, 2003). Extensive farming practices and consumption of chemical fertilizers sole are leading towards incessant diminution of organic matter from soil. It is possible only to substitute the losses of SOM the earlier by appliance of bio-manures like cow dung, poultry waste, farm yard manure etc. (Glaser *et al.*, 2001).

Organic wastes are full of macro and micro-nutrients but appliance of fresh organic material is not constantly eco- and human-friendly, being costly to apply as well. These elements usually have wide C: N ratio and possible to discharge more CO_2 when practiced to farming lands. Above the earlier one-and-half century, the quantity of carbon within our atmosphere in terms of carbon dioxide, methane and nitrous oxides, has been amplified by almost 30 percent. Higher amounts of the previously mentioned gasses, mostly carbon dioxide, are intensely concomitant with the global warming (Sparks, 2003). To composed down upcoming atmospheric C concentration, a worldwide yearly decline in CO_2 is obligatory. There are the numbers of techniques to diminish atmospheric CO_2. The carbon requisitioning is actually an extensive and long term storing of carbon in all the geographical levels. Moreover, it also was assessed long ago that fluctuations in the usage of land and thereby cultivation play really imperative role in the production of carbon dioxide, methane and nitrous oxide.

In current years, land use of organic wastes has arisen as an eye-catching and low cost substitute approach for waste controlling about the world. Nevertheless, the reutilizing of these wastes should be finished in such a way that it enhances the chemical, biological and physical properties of the soil along with curtailing the environment related problems (Pare *et al.*, 2000). Composting is a little cost and environment approachable method of the reutilization of waste material (Hoitink and Fahy, 1986; Millner *et al.*, 1998). In this procedure in the organic-type waste are rehabilitated biologically to an unstructured, constant and humus-like substance (following all the pre-requisite standardized conditions) which could be practiced and controlled without menacing with any environment-related impressions (Gallardo-Larva and Nogales, 1987; Millner *et al.,* 1998). Composted organic waste ingredients are considered for their efficiency to augment crop yields over uncomposted/raw ones owing to development chemical, biological and physical properties of the soil and abridged rate of mineralization process (Ahmad *et al.*, 2006).

The decay of organic ingredients is imperative to conclude the nutrient discharge pattern and ideal time for organic material deliverance. Carbon dioxide evolution is an effective indicator to find out the rate of organic matter decomposition, nutrient discharge pattern and eventually environment appropriateness of the organic waste material. In the current study, fruit and vegetable waste ingredients was composted and enhanced with urea-N. Rates of Mineralization of N-enriched compost and un-composted waste of fruit and vegetable along with similar quantity of N as in enhanced compost were computed by scrutiny of carbon dioxide evolution under the controlled laboratory conditions.

Compost preparation

Compost was arranged by means of a local composting machine comprising of drying, grinding and a processing sections. Waste of vegetable and fruit was collected by visiting numerous sites of the city. Composed organic-type of material was dried using air-drying mechanism for almost 24 hours in order to eradicate the unbalanced water contents and eliminate undesirable material from the waste. Then oven-drying was done exactly at 55ºC for a whole day and ground by electrical grinder to get fine particles. After that, the ground material was placed inside the composting machine in order to transfigure waste ingredients to the compost. About 40 percent of moisture was retained while composting the material. The whole process of composting was continued for 5 days and nights under organized and standardized conditions.

Composted material, which was about 300 kilograms, was then enhanced / intermingled with almost 30 kilograms of nitrogen fertilizer, hence, compost was composed of 10% nitrogen fertilizer. Both raw and properly composted waste ingredients were then examined for C and NPK contents as stated by Nelson and Sommers (1996) and Ryan *et al.* (2001). The carbon/nitrogen, carbon/phosphorus and carbon/potassium ratios were computed.

Calculation of the rates of mineralization of raw and composted organic materials

Rates of mineralization of fresh and composted organic ingredients were tested by the technique designated by Anderson, (1982). Fresh waste, fresh waste along with urea (that is equal to nitrogen existing in the nitrogen-enriched compost) and nitrogen-enriched compost were also mixed (1% of the weight of the soil) to flasks comprising of about 50 grams of non-sterilized soil. Almost 15 percent of moisture (volume/weight) was retained inside vessels with carbon dioxide-free water. The flasks were positioned inside the jars (500 milliliters volume) encompassing 2.5 normal sodium hydroxide to trap the evolved carbon dioxide. The previously mentioned jars were then sealed with sterilized covers and incubated at 30ºC for 21 days and nights. A control treatment (glass jar without flask) was involved in the trial as well. Then carbon dioxide confined inside sodium hydroxide was computed using titration along with 1.0 normal hydrochloric acid against phenolphthalein followed by precipitating with 1.0 normal barium chloride at diverse intermissions. At the completion, accumulative CO_2 evolved from dissimilar treatments was computed.

Carbon: nutrient ratio of fresh and composted organic wastes

The chemical structure of both fresh and composted organic wastes was calculated through laboratory examination and carbon: nutrient ratios were computed (Figure 1). The C: N ratio of the fresh (non-composted) organic waste crumpled to <2.00 mm was 27.0, which was abridged to 11.0 after 5 days composting procedure under ideal composting situations. The C: P ratio declined to 66.0 in case of composted organic waste over non-composted (raw) organic waste (158.5). Likewise, C: K ratio was abridged to 14.1 in case of composted organic waste over the non-composted organic waste (28.9).

Mineralization rates of fresh and composted organic ingredients

The mineralization rate study exposed that CO_2 discharge from N-enriched compost-amended soils was slower than that documented in case of both fresh organic waste and raw waste along with urea-enriched soil under standardized lab situations (Figure 2). There was consistent discharge of carbon dioxide (ranging from 22.5 to 57.0 milligrams per kilograms per day) from soil modified with the value-added completed product (N-enriched compost prepared from organic waste), demonstrating superior constancy of composted organic waste material (ended product) against the raw organic waste material. In case of modified soil, it fluctuated in range of 32 to 112 milligrams per kilogram per day and the uppermost evolution of carbon dioxide evolution was documented 14-days after incubation and later it dropped abruptly. The instantaneous deliverance of urea and fresh organic waste ensued in prompt mineralization of the concluding as the utmost CO_2 discharge was perceived just afterwards 4 days of incubation. After 4 days, there was a very severe diminution in the discharge of CO_2. Average evolution of CO_2 from the modified soil with urea along with organic material fluctuated from 36 to114 milligrams per kilogram per day.

Cumulative CO_2 evolved from fresh (non-composted) and composted organic waste

Cumulative CO_2 evolved from soil modified with raw, fresh plus urea and composted organic waste throughout 21 days is displayed in Figure 3. The soil modified with fresh (uncomposted) organic waste exhibited extreme cumulative CO_2 evolution (1661 mg kg-1 soil). Subsequent to it was the soil where the fresh organic waste was added along with the urea fertilizer and it was 1333 mg kg^{-1} soil. Smallest accumulative CO_2 evolution (1113 mg kg^{-1} soil) was perceived in case of composted organic waste material. On an average 80 mg kg^{-1} day^{-1} CO_2 was unconfined from raw (un-compost) organic waste modified soil whereas 65 mg kg^{-1} day^{-1} from raw organic waste plus urea and 55 mg kg^{-1} from the compost cured soil.

Carbon to nitrogen, phosphorus and potassium proportions of the composted raw organic waste treated soil were lessened from 27, 159.6 and 30.0 to11, 66 and 15.2 (on a normal basis) individually, which is a decent marker of stable humified organic matter in the completed compost product (Figure 1). The C: N proportion of humus is accounted for to be in the scope of 10 to 12 (Sahi, 2004). Nitrogen and in addition other large scale supplements were expanded in compost treated soil natural contrasted with the un-composted raw waste material. It may be because of diminishment in mass volume of the organic wastes during composting and its deterioration by different organisms. Comparable sort of perceptions were accounted for by different researchers (Holden, 1990; Cambardella *et al.,* 2003). Laboratory study carried out to explore the rate of mineralization from the soil modified either with fresh (uncomposted) or composted organic wastes exposed that mineralization of composted organic waste material (with little C: N proportion) in soils was greatly slower than that of the raw/un-composted organic waste (with great C: N ratio) under organized laboratory conditions (Figure 3). The results are in accord with the conclusions that cattle dung compost had fewer mineralization rate with 9:5 carbon/nitrogen ratio as compared to that of fresh cattle dung with a carbon/nitrogen ratio of 15:5 (FFTC, 1997). These results indicate that the composted organic wastes had extra constancy over un-composted organic waste and, therefore organic matter position of the soil may be enhanced by applying composted organic wastes as a soil amendment. This might further aid in retaining biotic action in the soil for lengthier time. Augmentation of the compost with N-fertilizer was lessened further by the carbon/nitrogen ratio and alleviated the organic material. When organic material comprising high quantity of nitrogen is practiced to the soil, fewer quantity of the initially applied organic material is decayed/vanished and therefore more is added to the soil (Kolay, 2000). It had been described that the accretion of the organic matter was more than dual owing to the compost appliance over similar quantity of fresh organic waste material (FFTC, 1997). Likewise, Ushio *et al.* (1997) described more organic matter deposition in the soil on adding the compost over the raw type of organic waste material.

In this study, it was also observed that the addition of urea-N (equivalent to the amount of N added in enriched compost) enhanced the activity of microbes (mineralization rate) and the highest CO_2 release was observed just after 4 day incubation (Figure 3). While in case of raw organic waste, mineralization increased as incubation proceeded, and the highest CO_2 release was recorded after 14 days incubation. Nitrogen application might have promoted microbial activity and caused rapid mineralization. Amelioration of organic ingredients having varied carbon/nitrogen ratio with nitrogen containing fertilizer was publicized to hasten the rottenness (Banger *et al.,* 1988). Numerous related experts have described that contraction of carbon/nitrogen ratio with nitrogen fertilizer augmented mineralization procedure (Mishra, 1992; Haug, 1993; Barker, 1997).

The study indicated that deliverance of urea-N along with fresh organic waste could overturn plant growth due to high mineralization rate and urea-N combined compost can recover crop productivity by constant and stable mineralization rate as we described previously (Ahmad *et al.,* 2006). Furthermore, high cumulative CO_2 discharge from uncomposted organic waste over composted organic waste (Figure 3) proposes that consumption of fresh or raw organic waste is not environment benign as it may possibly have detrimental effect on crops. Substantial application of effortlessly decomposable organic material viewing more production of CO_2 might cause an abridged situation inside the soil, oxygen paucity inside the roots of plants and the creation of detrimental material viz. phenolic compounds and organic acids (FFTC, 1997). Furthermore, high accumulative CO_2 discharge may possibly donate more towards greenhouse effect or global warming. Opposing to this, adding of organic fertilizer amendments will recover soil productiveness slowly and steadily in a time consuming discharge of nutrients, decline erosion of soil and percolation of the subsoil through refinement in physico-chemical properties of the soil and eventually upsurge the biomass (Sparks, 2003). This can upsurge carbon confiscation by about 0.1 to 42 Mega grams per hectares in expressions of total SOC and from about 0.1 to 4.5 percent in SOM content (Lal, 2001), therefore eventually diminish green house effect or global warming. So, the usage of N combined composted organic waste material will demonstrate helpful towards sustainable farming and environment.

References

Ahmad, R., A. Khalid, M. Arshad, Z.A. Zahir and M. Naveed. (2006). Effect of raw (un composted) and composted organic waste material on growth and yield of maize (*Zea mays* L.). *Soil & Environ.*, 25(2): 135-142.

Anderson J.P.E. (1982). Soil respiration. *In*: Methods of Soil Analysis: Part 2, Chemical and Microbiological Properties; A.L. Page, R.H. Miller and D.R. Keeney (eds.), Agronomy No. 9, American Society of Agronomy, Madison, WI.

Banger, K.C., K.K. Kapoor and M.M. Mishra. (1988). Effect of pyrite on conversion of nitrogen during composting. *Biol. Wastes.* 25: 227-231.

Barker, A.V. (1997). Composition and uses of compost. *In:* Agricultural uses of by-products and wastes. J.E. Rechigl, and H.C. Mackinnon (eds.), American Chemical Society, Washington, D.C.

Cambardella, C.A., T.L. Richard and A. Russell. (2003). Compost mineralization in soil as a function of composting process conditions. *European J. Soil Biol.*, 39: 117-127.

Food and Fertilizer Technology Center (FFTC). (1997). The decomposition of fresh and composted organic matter in soil. Hitoichi Shiga Research and Development Centre for Dairy Farming Kitano 2-3-5- 9, Kiyota-Ku, Sapporo 004-0862, Japan.

Gallardo-Larva, F., R. Nogales. (1987). Effect of application of town refuse compost on the soil plant system – A review. *Biol. Wastes* 19: 35-62.

Glaser, B., J. Lehman, M. Fuhrboter, D. Solomon and W. Zechand. (2001). Carbon and nitrogen mineralization in cultivated and natural savana soils of northern Tanzania. *Biol. Fertility. Soil.* 33: 301-309.

Haug R.T. (1993). The practical handbook of compost engineering. Lewis Publishers, Boca Raton, Fla. USA.

Hoitink, H.A.J. and P.C. Fahy. (1986). Basis for the control of soil borne plant pathogens with composts. *Ann. Rev. Phytopathol.*, 24: 39-114.

Holden, C. (1990). Process technology and market development for composted poultry manure: An overview of challenges and opportunities. p. 236-242. *In:* Proceeding National Poultry Waste Management Symposium.

Kolay, A.K. (2000). Basic Concepts of Soil Science. 2nd Ed. New Age International Publisher, New Delhi: 256.

Lal, R., (2001). Soil Carbon Sequestration and Greenhouse Effects. Soil Science Society of America. Special Bulletin # 57. Madison, WI: 236.

Millner P.D., L.J. Sikora, D.D. Kaufman and M.E. Simpson. (1998). Agricultural uses of biosolids and other recyclable municipal residues: 9-44. In: Agricultural uses of municipal, animal and industrial byproducts.

Mishra, M.M. (1992). Enrichment of organic manures with fertilizers. p. 48-60. *In*: Non Traditional Sector for Fertilizer Use. H.L.S. Tandon (ed.), FDCO, New Delhi.

Nelson, D.W. and L.E. Sommers. (1996). Total carbon, organic carbon and organic matter. p. 961-1010. *In*: Methods of Soil Analysis: Part 3, Chemical Methods. J.M. Bigham (ed.). Amer. Society Agron. Madison, WI.

Pare, T., H. Dinel. And M. Schnitzer. (2000). Carbon and nitrogen mineralization in soil amended with nontabletized and tabletized poultry manure. *Can. J. Soil Sci.*, 80: 271-282.

Ryan, J., G. Estefan. and A. Rashid. (2001). Soil and Plant Analysis: Laboratory Mannual. International Centre for Agriculture Research in Dry Areas (ICARDA) Aleppo: 172.

Sahi, V.N. (2004). Fundamentals of Soil. Kalyani publishers. New Delhi: 301.

Sparks, D.L. 2003. Environmental Soil Chemistry. 2nd Ed. Academic press. Amsterdam. 352 p.

Ushio, S., N. Suzuki. And N. Nakajima. (1997). Evaluation of quality of livestock manure compost for efficient utilization (4). Abstract of the Annual Meeting of Japannese Society of Soil Science and Plant Nutrition. (In Japanese).

Zechand, W. and I. Kogel-Kanabner. (1996). Patterns and regulations of organic matter transformation in soil: Litter decomposition and humification. p. 303-334. *In*: flux control in biological systems. E.D. Schulze (ed.). Academic Press, San Diego, CA.

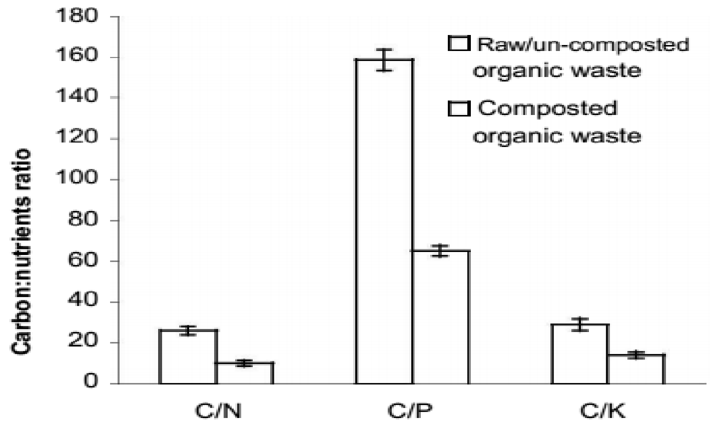

Figure 1: Carbon: nutrient ratios of raw/un-composted and composted organic waste material

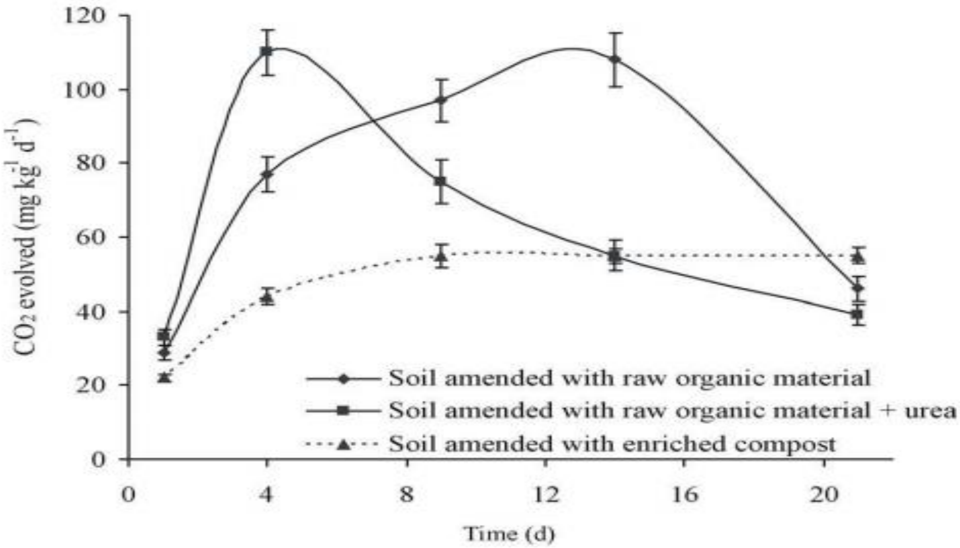

Figure 2: Mineralization rates of raw, raw*urea and composted organic waste amended soil

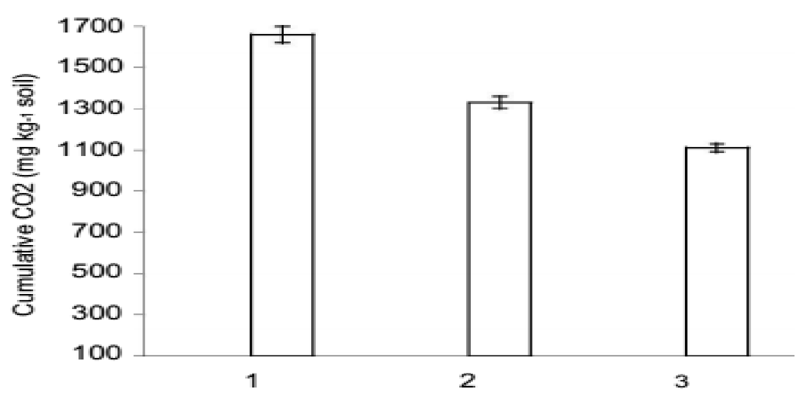

Figure 2: Comulative CO_2 evolved from soil amended with raw organic waste material (1), raw organic waste material + urea (2) and urea enriched compost (3)