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Dynamics of Carbon Dioxide Evolution and Microbial Population Changes During Vermicomposting of Different Biomass Materials

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Abstract

A study was conducted to evaluate carbon dioxide (CO_2) evolution and microbial population during vermicomposting of different organic biomass materials. Various combinations of organic wastes such as farmyard manure (FYM), goat manure, animal feed waste and garden waste were used for vermicompost preparation. The results showed that CO_2 evolution increased up to 45 days of vermicomposting and gradually decreased thereafter, indicating stabilization of organic matter. The highest CO_2 evolution was recorded in treatments containing FYM, goat manure and animal feed waste. Microbial analysis revealed that fungal, bacterial and actinomycetes populations were significantly higher in vermicompost prepared from nutrient-rich biomass combinations. The enhanced microbial activity was attributed to favourable conditions and availability of easily decomposable organic substrates. Overall, the study indicated that appropriate biomass combinations improve microbial activity and decomposition efficiency, resulting in high-quality vermicompost.

Key words : Mineralization, CO_2 evolution, vermicomposting, microbial population.

Organic manures such as farmyard manure (FYM), cow dung, poultry manure and biogas slurry have long been important inputs for maintaining soil fertility and sustaining crop yields. Municipal solid waste generated from human activities is a major environmental concern, particularly in urban areas. However, these organic wastes can serve as valuable sources of organic matter and nutrients for soil improvement when properly processed. Several earthworm species are capable of consuming a wide range of organic wastes, including sewage sludge, animal waste, crop residues and garden wastes (Edward *et al*., 1985). Direct application of these wastes to agricultural fields is not recommended due to their wider C:N ratio, which can lead to nutrient immobilization and the production of phytotoxic substances during decomposition.

Vermicomposting is a biological process in which earthworms and microorganisms convert organic wastes into a stable, odourless, humus-like material (Aira *et al*., 2007). Earthworms modify the substrate and enhance microbial activity, while microorganisms carry out the biochemical decomposition of organic materials (Suthar, 2007). The resulting vermicompost is a nutrient-rich organic manure containing nitrogen (2–3%), phosphorus (1.55–2.25%), potassium (1.85–2.25%), micronutrients, beneficial microbes, plant growth hormones and enzymes (Domínguez, 2004). Vermicompost improves soil fertility, enhances water-holding capacity and enriches soil with beneficial microorganisms that produce enzymes such as phosphatases and cellulases. It also promotes seed germination, plant growth and crop yield (Gajalakshmi *et al*. 2005). Due to its low C:N ratio, high porosity and plant-available nutrients, vermicompost is considered an effective and sustainable method for recycling organic waste and improving soil health.

Materials and Methodology

The present investigation pertaining to "Dynamics of carbon dioxide evolution and microbial population changes during vermicomposting of different biomass material" was carried out during the year 2022-2023 at the Department of Soil Science and Agril. Chemistry, Post Graduate Institute, MPKV, Rahuri. The primary objective was to assess the CO2 evolution as an indicator of microbial activity. The experiment was laid out in randomized block design with eight treatments (Table 1) and three replications. During vermicomposting period, the samples were collected at an interval of 15 days. i.e., 0, 15, 30, 45 and at 60 days. These samples were analyzed for CO_2 evolution and characterization.

Table 1. Treatment Details

Treatments	**Particulars**
T_1 - Sorghum Research Project	FYM + Garden waste (2:1)
T_2 - Water Management Scheme	FYM + Garden waste (2:1)
T_3 - Hostel Premises	FYM + Garden waste (2:1)
T_4 - Cotton Research Project	FYM + Soil + Garden waste (2:1:1)
T_5 - Irrigation Water Management	FYM + Soil + Garden waste (2:1:1)
T_6 - Cattle Farm	FYM + Animal feed waste (2:1)
T_7 - Organic Farm	FYM + Goat manure + Animal feed waste (2:0.5:1)
T_8 - Integrated Farming System	FYM + Goat manure + Animal feed waste (2:0.5:1)

Formula : CO_2 Evolution (mg CO_2 day^{-1}) = (NaOH volume – Burette reading

Statistical tool used for analysis : The result obtained were statistically analysed in RBD and appropriately interpreted as suggested by Panse and Sukhatme, 1985.

CO_2 Evolution from Vermicompost by Alkali trap method (Anderson, 1982)

25g of well moist vermicompost sample was taken in a plastic bottle

↓

Hung a test tube containing 10ml of 1N NaOH solution with thread in a plastic bottle and tighten the lid of bottle to ensure that there is no leakage

↓

Incubated it for 24 hrs and then estimated the evolved CO_2

↓

For estimation of evolved CO_2, the test tube containing NaOH solution was taken out and the excess alkali was back titrated with HCl after addition of excess $BaCl_2$ solution by using phenolphthalein as a indicator.

↓

Burette reading was recorded as a pink colour disappears

Results and Discussion

CO_2 Evolution: The data regarding changes in carbon dioxide (CO_2) evolution from different organic wastes inoculated with earthworms are presented in Table 2 and graphically illustrated in Fig. 1. CO_2 evolution during vermicomposting was influenced by the moisture content and the type of biomass used. The rate of CO_2 evolution increased up to 45 days and thereafter decreased. At 15 days, the highest CO_2 evolution was recorded in treatment T_8 - IFS (68.93 mg CO_2 day^{-1}), which contained biomass comprising FYM + goat manure + animal feed waste. This was higher than all other treatments, followed by T_7 (60.60 mg CO_2 day^{-1}). A similar trend was observed at 30 and 45 days of vermicomposting. At 60 days, a decline in CO_2 evolution was observed; however, the highest value was still recorded in T_8 - IFS (137.13 mg CO_2 day^{-1}), containing FYM + goat manure + animal feed waste, compared to other treatments, except T_7 - OF, which was statistically at par. The percentage increase in CO_2 evolution in T_8 - IFS and T_7 - OF was 98.94% and 121%, respectively.

Table 2. CO_2 evolution (mg CO_2 day^{-1}) from vermicompost at various periodical stages

Tr. No.	Location	Days of Vermicomposting				
		15	30	45	60	Total
T_1	Sorghum Research Project (FYM + Garden waste)	39.60	73.33	104.87	94.60	312.4
T_2	Water Management Scheme (FYM + Garden waste)	49.86	85.80	134.93	123.20	393.79
T_3	Hostel premises (FYM + Garden waste)	46.93	90.20	132.00	111.46	380.59
T_4	Cotton Research Project (FYM + Soil + Garden waste)	35.20	64.00	112.20	97.53	308.93
T_5	Irrigation Water Management (FYM + Soil + Garden waste)	37.40	76.26	107.80	93.13	314.59
T_6	Cattle Farm (FYM + Animal feed waste)	52.80	96.80	121.73	105.60	375.93
T_7	Organic Farm (FYM + Goat manure + Animal feed waste)	60.60	103.40	145.20	134.20	443.40
T_8	Integrated Farming System (FYM + Goat manure + Animal feed waste)	68.93	110.70	156.20	137.13	472.96
SE m(±)		1.086	1.192	1.243	1.130	
CD at 5%		3.294	3.618	3.771	3.427	

Overall, the cumulative CO_2 evolved from the studied beds ranged from 308.93 to 472.96 mg CO_2 during the vermicomposting period.

The changes in CO_2 evolution during vermicomposting may be attributed to the rapid decomposition of easily degradable organic matter and the release of carbon during microbial respiration (Dume *et al.*, 2021). A decrease in CO_2 evolution indicates increasing stability of the organic matter (Atiyeh *et al.*, 2000). The findings of the present study are in agreement with those reported by Hossain *et al.* (2017), who studied CO_2 evolution and carbon mineralization using vermicompost. They reported that the maximum CO_2 emission rate was observed in chicken manure (410.67 mg CO_2 $week^{-1}$ kg^{-1} soil) at the 5th week of incubation, followed by rice straw (374 mg CO_2 $week^{-1}$ kg^{-1} soil), cow dung (211 mg CO_2 $week^{-1}$ kg^{-1} soil), vermicompost (208 mg CO_2 $week^{-1}$ kg^{-1} soil), and rice husk biochar (116 mg CO_2 $week^{-1}$ kg^{-1} soil).

Microbial Population : The microbial population (Table 3), including fungi, bacteria, and actinomycetes, was studied in vermicompost prepared from different biomass sources after the completion of the vermicomposting process. Vermicomposting is the result of the combined activity of microorganisms and earthworms. At 60 days, the fungal population ranged from 16.77 to 24.27 x 10^4 cfu g^{-1}. The highest fungal population was recorded in T_7 - OF (24.27 x 10^4 cfu g^{-1}), containing biomass composed of FYM + goat manure + animal feed waste, which was higher than the other treatments, except T_8 - IFS and T_5 - IWM, which were statistically at par.

The bacterial population was also highest in T_7 - OF (76.06 × 10^7 cfu g^{-1}) at 60 days, while T_8 - IFS, containing biomass FYM + goat manure + animal feed waste, was found to be statistically at par. However, the lowest bacterial population was recorded in T_3 - HP (61.40 x

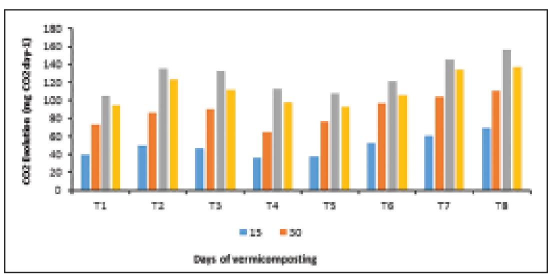

Fig. 1. CO_2 evolution (mg CO_2 day^{-1}) from vermicompost at various periodical stages

Table 3. Microbial Count in vermicompost

Tr. No.	Location	Days of Vermicomposting (60 Days)		
		Bacteria (cfu x 10^7 g^{-1})	**Fungi (cfu x 10^4 g^{-1})**	**Actinomycetes (cfu x 10^5 g^{-1})**
T_1	Sorghum Research Project (FYM + Garden waste)	61.40	17.83	34.44
T_2	Water Management Scheme (FYM + Garden waste)	68.63	21.60	40.33
T_3	Hostel premises (FYM + Garden waste)	61.73	16.77	38.99
T_4	Cotton Research Project (FYM + Soil + Garden waste)	63.97	19.83	38.11
T_5	Irrigation Water Management (FYM + Soil + Garden waste)	69.06	22.50	44.10
T_6	Cattle Farm (FYM + Animal feed waste)	62.26	20.73	35.77
T_7	Organic Farm (FYM + Goat manure + Animal feed waste)	76.06	24.27	46.88
T_8	Integrated Farming System (FYM + Goat manure + Animal feed waste)	74.07	23.40	44.55
SE m(±)		0.747	0.677	0.758
CD at 5%		2.267	2.055	2.301

10^7 cfu g^{-1}), which contained biomass composed of FYM + garden waste. After the completion of the vermicomposting period, the actinomycetes population was also recorded and found to differ significantly among the treatments (Fig. 2). At 60 days, T_7 - Organic Farm (46.88 x 10^5 cfu g^{-1}) was found to be superior over the other treatments, followed by T_8 - IFS (44.55 x 10^5 cfu g^{-1}) and T_5 - IWM (44.10 x 10^5 cfu g^{-1}). However, T_1 - SRP (34.44 x 10^5 cfu g^{-1}) recorded the lowest population of actinomycetes among all treatments. The higher microbial population in vermicompost may be attributed to the ingestion of nutrient-rich biomass, which provides energy and substrates for microbial growth, the maintenance of optimum moisture during vermicomposting, and favourable conditions within the earthworm gut that promote microbial proliferation (Tiwari *et al*., 1989). The findings of the present study are in agreement with those of Meenatchi *et al*. (2009), who reported bacterial, fungal and actinomycetes populations in vermicompost prepared from kitchen waste with Perionyx excavatus as 65 x 10^7 cfu g^{-1}, 10 x 10^3 cfu g^{-1} and 15 x 10^4 cfu g^{-1}, respectively.

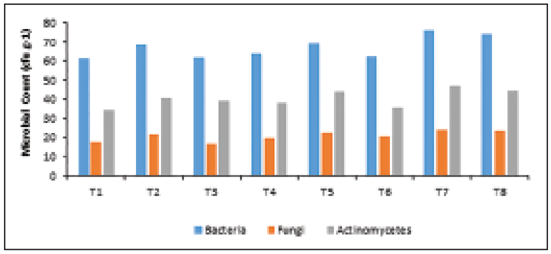

Fig. 2. Microbial Count in vermicompost

Conclusion

The study revealed that the type of biomass used in vermicomposting significantly influenced CO_2 evolution and microbial population. The treatment containing FYM, goat manure and animal feed waste (T_7 - OF and T_8 - IFS) recorded higher CO_2 evolution and greater populations of fungi, bacteria and actinomycetes compared to other treatments. This indicates enhanced microbial activity and faster decomposition of organic matter. Therefore, these biomass combinations are suitable for producing nutrient-rich and biologically active vermicompost.

References

Aira, M., Monroy F. and Dominguez, J. 2006. C:N ratio strongly affects the population structure of Eisenia foetida in vermicomposting systems. European Journal of Soil Biology 42(1), 5127-5131.

Atiyeh, Rola M., Jorge Dominguez, Scot Scubler and Clive A. Edwards. 2000. Changes in biochemical properties of cow manure during processing by earthworms (Eisenia Andrei, Bouche) and the effect on seedling growth, Pedobiologia 44, 709-724.

Domínguez, J. 2004. State-of-the-Art and New Perspectives on Vermicomposting Research. In: Edwards, C.A., Ed., Earthworm Ecology, CRC Press, Boca Raton, FL, 401-424.

Dume, B., Hanc, A., Svehla, P., Míchal, P., Chane, A. D. and Nigussie, A. 2021. Carbon Dioxide and Methane Emissions during the Composting and Vermicomposting of Sewage Sludge under the Effect of Different Proportions of Straw Pellets. Atmosphere 12(11), 1380.

Edward, C. A., Burrows, I., Fletcher, K. E. and Jone, B. A. 1985. The use of earthworms for composting farm wastes. In "Composting of Agricultural and Other Wastes". Edn by J. K. R. Gasser. 229-242.

Gajlakshmi, S., Ramasamy, E. V. and Abbasi, S. A. 2005. Vermicomposting of different form of water hyacinth by the earthworm Eudrilus eugeniae, Kinberg. Bioresource Technology 80, 131-135.

Hossain, M. B., Rahman, M. M. and Biswas, J. C. 2017. Carbon mineralization and carbon dioxide emission from organic matter added soil under different temperature regimes. International Journal of Recycling Organic Waste 6, 311–319.

Meenatchi, R., Giraddi, R. S., Awaknavar, J. S. and Biradar, D. P. 2009. Effect of food substrates and earthworm species on microbial activity in vermicompost and vermiwash. Journal of Agricultural Science. 22(5), 1020-1022.

Panse, V. G. and Sukhatme, P. V. 1965. Statistical Methods for Agricultural Worker. IV Ed. ICAR, New Delhi.

Suthar, S. 2007. Bioconversion of post-harvest crop residues and cattle shed manure into value added products using earthworm Eudrilus eugeniae (king berg). Ecological Engineering 32(3), 206-214.

Tiwari, S. and Mishra, R. 1989. Microbial population and enzyme activities in earthworm casts and in the surrounding soil of pineapple plantation. Biology and