Greenhouse gas emissions assessment in composting from biostabilized municipal solid waste.

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Introduction

European Union (EU) promotes a new plan of the waste management attending to the Circular Economy Package of the EU (Directive EU 2018/851). In the Valencian Community, the Spanish region where Castelló de la Plana is located, published its Integrated Municipal Solid Waste Plan (Decree 55/2019) that incorporates a mandatory separate biowaste collection (Gallardo et al., 2021). Municipal solid waste (MSW) is characterized by significant amounts of organic biowaste which must be adequately treated to avoid greenhouse gas emissions generated from their accumulation and disposal.

Therefore, there is a growing interest in the study of GHG emissions of large-scale windrow composting method and in the search for management practices that minimize their production. The characteristics of the starting nitrogen (N) and carbon (C) resources affect the physic-chemical properties of the pile and consequently govern the processes leading to the formation, diffusion and transport of GHGs. The main objective of the present study was to evaluate the impact of composting process on methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions, in biowaste treatment at large scale.

Materials & Methods

This field experiment was carried out in Sant Mateu, Castelló de la Plana, Spain (40°28'19.2"N, 0°13' 17.8"W), during 180 days. Six windrow composting piles (7,800 kg f.m) of 6.5 m × 1.5 m × 3 m (length × height × width) using olive mill waste (OMW) (kept constant in all mixtures, 65% f.m.), olive leaves waste (OLW), urban pruning residues (UPR) and OLW+UPR (1:1, w/w) as a source of C and biostabilized materials of urban waste management plants from Guadassuar, Valencia (MBT1) and Algimia, Castellón (MBT2) as a source of N (Table1). The initial moisture content of the mixed raw material is set at about 60 wt %. The piles was managed as an industrial compost pile, within a period of 20 days turning using a mechanical windrow turner machine and periodic pressurised watering. The piles were configured by establishing a correlation between volume, fresh matter and dry matter, based on the values of moisture and apparent density of each ingredient. All the materials were chosen following criteria of proximity and availability.

Static opaque closed chamber technique (volume: 0.007 m^3, area: 0.049 m^2) was used to measure CO_2, CH_4 and N_2O from the top of the compost piles with a design similar to that described by Sánchez-Monedero et al. (2010). Samples were taken 11 times at: 0, 7, 15, 30, 30, 52, 65, 79, 95, 122, 148 and 182 days after the start of composting. The chambers were inserted 10 cm into the compost piles and air samples were taken at 0, 15 and 30 minutes using disposable syringes. The gas flows were pumped several times before sampling to achieve homogeneous mixing of the air within the chamber space (Marín-Martínez et al., 2021). Samples were transferred into 20 ml glass vials for analysis by gas chromatography (Agilent 7890B).

Table1. Physico-chemical properties initial mixed compost raw material.

	OMW	UPR	OLW	MBT1	MBT2
Moisture (%)	58.9	29.4	28.5	26.4	30.1
BD (g cm^3)	0.866	0.183	0.097	0.319	0.373
pH	6.7	7.5	6.1	6.9	7.6
EC (dS m^{-1})	3.05	2.71	1.34	6.50	5.07
TOC (%)	50.6	37.1	45.5	33.8	31.35
TN (%)	0.81	1.22	1.21	1.65	1.73
TOC/TN	62.51	30.31	37.67	20.46	18.12
PPH (mg kg^{-1})	5757	2492	6295	1458	2680

BD: Bulk Density; EC: electrical conductivity; TOC: total organic C; TN: total N; PPH: polyphenols.

Each gas flux was calculated from a single determination at the end of the closure by transforming the gas measurement of N_2O, CH_4 and CO_2, ppm to mg N_2O, CH_4 and CO_2 m^2 day^{-1}, respectively (Vico et al., 2020). Data analysis was performed with Infostat® statistical software (Di Rienzo et al., 2020). One-way analysis of variance (ANOVA) and the least significant difference (LSD) test at $P < 0.05$ were used to assess the significance of differences among the values of each parameter studied during composting. Daily GHG fluxes were analyzed using a generalized linear mixed model. Correlations between manure and bulking agent sources with GHG fluxes were determined by Kruskal-Wallis test.

Results & Discussion

At the end of the sampling, no significant differences were found in the effect of bulking agents on N_20, CH_4 and CO_2 fluxes. The dynamics of the cumulative flow of emissions is similar for each of bulking agents assessed. There is a slight trend towards higher N_2O and CO_2 emissions from UPR+OLW, and CH_4 of the OLW treatment. On the other hand, significant differences can be observed in the different types of MBT in the total cumulative GHG emission ($p<0.0001$). For each of the gases assessed, the emission has been MBT1>MBT2 (Fig. 1). From sampling day 95, 52 and 7 of N_20, CH_4 and $C0_2$ respectively emissions are significant and higher in MBT1.

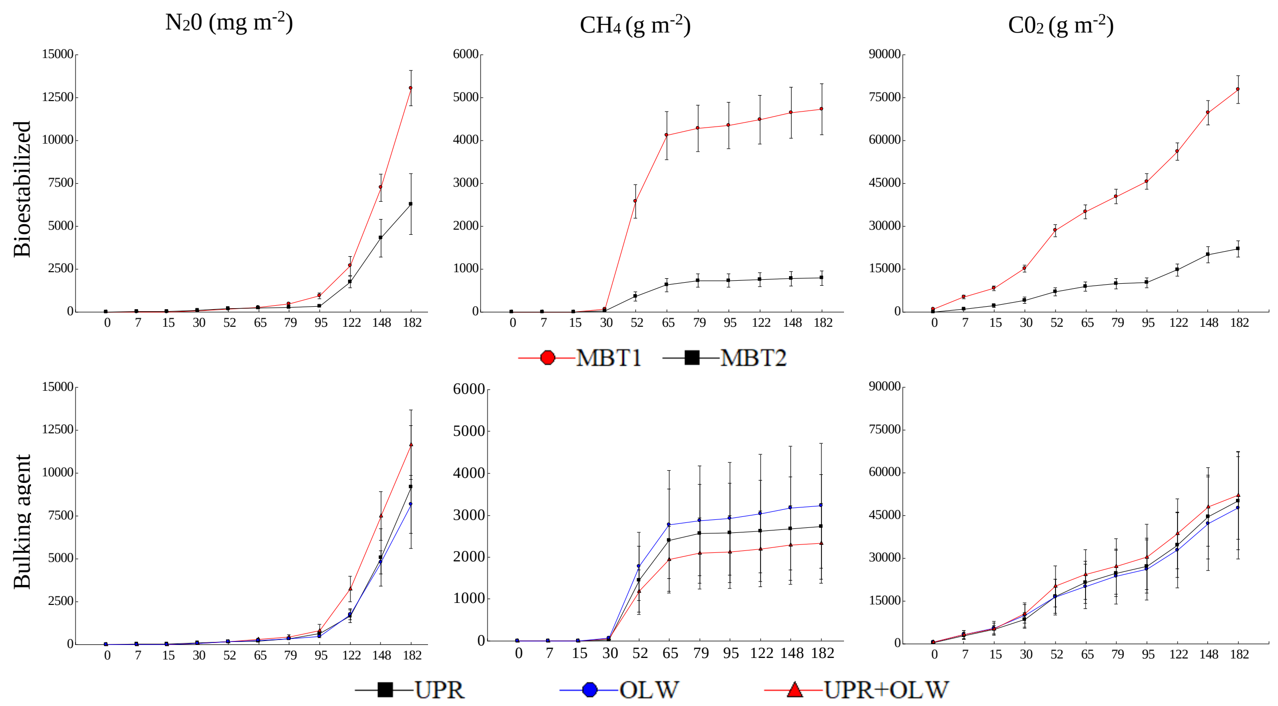

Figure 1. Evolution of N_2O, CH_4 and CO_2 fluxes during windrow composting. Bars represent standard error.

Conclusion

The gas emissions from composting process can be minimized by careful management during the treatment. The emissions generated during composting of biowaste were regulated by the composition of the starting mixtures. GHG emissions were mainly affected by the use of MBT in the starting mixture.

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