COMPARATIVE EVALUATION OF COMPOST STABILITY MEASUREMENT METHODS

CHRONI C., LASARIDI K., KYRIACOU A., ZORPAS A.A. and ABELIOTIS K.

Harokopio University, Athens, Greece
E-mail: klasaridi@hua.gr

ABSTRACT

The performance of the composting process and the quality of the end-product (the compost), mainly assessed by stability, are governed by the waste composition and waste management strategies. Although a few indices has been devised for compost stability assessment, tracing parameters which effectively reflect the stabilisation process of organic matter during composting is yet to be addressed.

To assess the quality of the compost, the combined application of independent methodologies (microbiological, physical and chemical) for the determination of microbial activity/evolution is needed. The objective of this study was to focus on the microbial activity variation, in the way this is assessed through the respiration rate, during composting of a variety of organic waste, with ultimate aim to evaluate their potential to serve as stability indicators. Therefore, it reports on assessing compost stability during composting of poultry manure; source separated biowaste; mixtures of sludge and garden clippings; mixture with sludge derived from beverage production, paper pulp, mushroom substrate, horse manure; mixture with beverage sludge, mushroom substrate, horse and chicken manure. The different substrates were composted using various composting systems (windrows, pilot or full scale systems, compost bins) and monitored, from raw to stabilised material (approximately 3-5 months). In each case the composting process was assessed through the determination of the respiration activity (using the Specific Oxygen Uptake Rate - SOUR test), microbial counts and a number of other parameters, such C/N, temperature, pH, electrical conductivity, moisture and volatile solids content. Standard procedures for compost sampling and selective substrates were used for the cultivation and enumeration of total bacteria, bacteria with resistance to antibiotics, total coliforms and Escherichia coli. In all runs, the compost temperature reached levels above 55 oC, proper for the sustainment of thermophilic microorganisms, regardless of the inherent differences of raw materials. The physical and chemical parameters examined varied depending on the composting material. The respiration rate (SOUR test) for all substrates increased at the beginning of the active composting phase, as complex compounds were broken down to simpler, more easily degradable ones. The analysis of the measurements indicate that there is a correlation between composting time and some physicochemical parameters, such as intensity of water evaporation and volatile solids reduction. Results of the microbial community dynamics analysis suggested that for all materials examined the microflora characterising the process was spontaneously developed, with no signs of inhibition, as their metabolic activity drives the process and overrides substrate differences.

The results of this study are expected to contribute to the improvement of our understanding of the stabilisation process, and to the refinement of the available methodologies for the estimation of respiration rate, in a way that their inherent limitations on using exclusively compost after sampling will be overcome.

Keywords: respiration rate, compost, stability.

1. Introduction

The performance of the composting process and the quality of the end-product (the compost), mainly assessed by stability (i.e. the degree to which readily biodegradable organic matter has

decomposed Lasaridi and Stentiford, 1998a), are governed by the waste composition and the process management strategies. Although several indices have been devised for compost stability assessment, parameters which effectively reflect the stabilisation process of organic matter during composting are yet to be defined (Raj & Antil, 2011; Chroni *et al*., 2009). To assess the quality of compost, the combined application of independent methodologies (microbiological, physical and chemical) for the determination of microbial activity/evolution is needed. The objective of this study was to focus on the microbial activity variation and the methods this can be assessed through the respiration rate, during composting of a variety of different organic waste, with ultimate aim to evaluate their potential to serve as stability indicators.

2. Methodology

A total of eight different substrate mixtures: poultry manure (PM1 and PM2); mixtures of sludge and garden clippings (GWS, GWS.M, GWS.L and GWS.ML); mixture with beverage sludge, paper pulp, mushroom substrate, horse manure (BIO.A); and mixture with beverage sludge, mushroom substrate, manures (BIO.B), were monitored from raw substrate to stabilised compost (approximately for 3–5 months each). The substrates were composted using various composting systems (windrows, pilot or full scale systems, compost bins). In all cases, sampling intervals were determined by the temperature and moisture profile of each composting mixture, with a good control of other limiting factors, such as aeration etc. In each case, the composting process was assessed through the determination of the respiration activity (using the Specific Oxygen Uptake Rate - SOUR test), microbial counts and a number of other parameters, such C/N, temperature, pH, electrical conductivity (EC), moisture (MC) and volatile solids (VS) content. Compost stability was determined in duplicates using a modification of the SOUR test, run at 30 ˚C (Lasaridi & Stentiford, 1998a, b). Moisture content (% ww), VS (% dw), EC and the pH values were measured according to FCQAO, 1994. The VS reduction (VS_{red},%) was calculated on a constant ash content basis (Haug, 1993). Culturable microflora was monitored through the enumeration of total aerobic bacteria, bacteria with resistance to antibiotics, total coliforms and *Escherichia coli*. Microbial groups were determined by the dilution plate count technique and the colony forming units (CFU/g DW). Total coliforms and *Escherichia coli* were isolated on Chromocult agar (Merck, 24h, 37˚C), total aerobic bacteria on Nutrient Agar (LabM, 48h, 30˚C), while actinobacteria were estimated according to Clark (1994). Cultivable Erythromycine and Tetracycline resistant bacteria were enumerated according to Mitchel Jr. *et al*. (2008).

3. Results

In all runs, the compost temperature reached levels above 50 ^{o}C, within the first few days of processing, which were suitable for sustaining thermophilic microorganisms. In Table 1, the values of pH, VS and EC of initial and the last sample, as well as the max temperature values and the VS_{red} (%), are presented.

Table 1: Change of selected parameters during the composting process.

	T_{max} (°C)	MC (%) day 0/ last sample	pH day 0/ last sample	E.C. (mS/cm) day 0/ last sample	V.S. red (%)
BIO.A	75.6	62.5 / 27.3	7.8 / 9.1	3.01 / 3.55	40.2
BIO.B	66.5	51.2 / 23.6	7.9 / 9.0	1.80 / 2.70	-
PM.A	72.7	47.5 / 48.3	8.8 / 9.7	8.35 / 5.76	41.2
PM.B	65.5	65.8 / 18.6	7.3 / 9.9	3.70 / 3.92	58.8
GWS	52.0	66.6 / 63.4	8.3 / 8.4	2.52 / 1.46	63.5
GWS.M	51.1	63.8 / 59.9	8.3 / 8.3	2.21 / 1.69	65.1
GWS.L	52.3	66.6 / 59.4	8.0 / 8.6	2.13 / 1.94	63.2
GWS.ML	55.2	67.3 / 66.9	8.0 / 8.5	2.39 / 2.12	67.6

The respiration rate (SOUR test) for all substrates demonstrated high values at the beginning of the active composting phase, as complex compounds were broken down to simpler, more easily degradable ones, reaching values of 3.9 to 8.4 mg O_2/g VS/hr (±0.92). Thereafter, the respiration rate gradually declined as to reach values below 2.0 mg O_2/g VS/hr by the end of the monitoring period. The population of *E. coli* declined below the detection limit for all runs. Coliforms population decreased during the thermophilic phase, but re-emerged in the cooling phase. Microbial counts of bacteria resistant to Erythromycine and Tetracycline were performed on BIO.A, BIO.B. and PM.B. The populations of bacteria resistant to Erythromycine and Tetracycline declined during the thermophilic phase of the composting process, but were not decimated in every case.

4. Conclusions

The results of monitoring of the microbial population dynamics suggested that for all materials the microflora characterising the process was developed without signs of inhibition. The microbial metabolic activity overrode substrates differences. The high temperatures are necessary, but not sufficient for the decimation of pathogens. The key players to the latter are the exposure time to high temperatures and the composting management system. The SOUR-test proved to be useful as an indicator of compost stabilisation.

REFERENCES

1. Lasaridi K.E. and Stentiford E.I. (1998a), A Simple Respirometric Technique for Assessing Compost Stability, Water Res., **32 (12),** 3717-3723.
2. Lasaridi K.E. and Stentiford E.I. (1998b), Biological parameters for composting stability assessment and process stabilization, Acta Hort., **469**,119-128.
3. Chroni C., Kyriacou A., Manios T. and Lasaridi K.E. (2009), Investigation of the microbial community structure and activity as indicators of compost stability and composting process evolution, Bioresource Technol., **100**, 3745-3750.
4. Raj D. and Antil R.S. (2011), Evaluation of maturity and stability parameters of composts prepared from agro-industrial wastes, Bioresource Technol.,**102**, 2868- 2873.
5. FCQAO (Federal Compost Quality Assurance Organisation) (1994) Methods Book for the Analysis of Compost, Kompost- Information Ne. 230, Budesgutegemeinschaft Kompost e.V. Germany, University of Essen.
6. Haug R.T. (1993), The Practical Book of Compost Engineering, Lewis Publishers, Boca Raton.
7. Clark F.E. (1994), 'Actinomycetes' In: R.W. Weaver, J.S. Angle and P.S. Bottmley (Eds.), Methods of Soil Analysis, Part 2. Madisson, WI: SSSA,1498-1501.