Monitoring the composting process through respirometric techniques

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Abstract

Under the approach of EU strategy *Zero Waste Europe*, there is a current priority to reduce to zero the amount of waste that ends up being deposited in landfill. To achieve the zero goal, composting is presented as a sustainable technique for the proper transformation of organic waste into products that can act as suitable amendments to improve soil properties, thus giving an economic and ecological value to what was previously a residue (Pascual, 1997; Veeken and Hamelers, 2002; Zbytniewski and Buszewski, 2005). In order for its effects on the receiving soil to be beneficial, it is necessary that the application of them occurs in adequate conditions of maturity and stability.

Among the many parameters that exist to monitor the evolution within the composting process, there have been many effective works using respirometric techniques performed by the measurement of impedance as a rapid method for the detection of bacterial activity (Yang and Bashir, 2008). The objective of this study was to determine the stability of a biosolid throughout its composting process by respirometric techniques.

With the purpose of achieving this objective, 28 samples of composting material based on 50% sewage sludge, 37.5% sawdust and 12.5% straw, were collected from a wastewater treatment plant,. Six points were sampled through the closed composting tunnels and an additional sample in the outer maturation pile. The points inside the tunnel were separated from the other by a week of residence, omitting the first week because of the heterogeneity within the mixture. At each sampling point, 4 samples were collected transverse to the direction of advance in the tunnels, with random depth and always below the first 10 cm of the surface.

In each of the samples, three analytical replicas were made and it was determined the Total Humic Extract, (MAPA, 1986) and the Humic and Fulvic fraction. From the Total Humic Extract, the Fulvic fraction was obtained by acidifying the medium below the pH value <1 at a constant temperature for 12 h. Fulvic acids and other soluble non-humic substances were separated by taking the supernatant (Swift, 1996). The Humic fraction was obtained by difference between the two previous extracts. All the extracts were subjected to oxidation by dichromate (Sims and Haby, 1971) to quantify their carbon content, expressed in mg/L.

Regarding respirometry, indirect methods of CO_2 production were used through measuring the variation over time of the electrical impedance. For the detection of microbiological activity, the Bactrac® system automatically recorded the absolute changes in impedance, in regular time intervals and at a constant temperature of 25ºC over 96h.

The results and the evolution of the respirometric values (mg CO_2/kg·h), the values of Total Humic Extract, Fulvic extract and Humic extract (in mg/L), compared to the time of composting showed similar tendencies as Table 1 summarizes. The CO_2 accumulated after 96h of incubation shows a progressive increase in time. This trend is maintained throughout the process, except for the accumulated value at 28 days. This fact can be attributed to a slight increase in the proportion of easily biodegradable materials originated in the early transformation of the lignocellulosic substances from the bulking agents, which is concordant with the results obtained by other authors (Said-Pullicino, 2007; Gómez-Brandón, 2008; Soriano-Disla, 2010).

The same tendency was observed for the results obteined for organic extracts in wich two phases can be appreciated, one from the beginning of the sampling until day 35 and another from day 35 until the end of the process.

These differences are associated with the predominance of one of the two dynamics within the composting process, the decomposition of organic matter and the humification. The first phase produces the

transformation of complex lignocellulosic substances into more easily oxidizable chemical compounds, with an increase in microbiological activity, deriving to the thermophilic stage and increasing the proportion of oxidizing carbon together with other more volatile ammoniac particles and moisture, especially when high temperatures are reached. In the second stage, there is a general reduction of the more labile matter and a global transformation into more complex compounds represented by the humic fraction.

Table 1. Comparison of the evolution of respirometric values and organic extracts with days of composting.

Sample (days)	Respirometry (mg CO_2/kg·h)	Total Humic Extract (mg/L)	Fulvic Extract (mg/L)	Humic Extract (mg/L)
14	25,47	774,64	215,65	358,99
21	19,84	728,47	233,36	420,11
28	25,01	753,83	299,06	404,76
35	22,98	813,37	236,26	577,11
42	19,44	720,27	239,30	330,97
49	12,23	606,75	187,68	344,57
56	12,08	538,55	140,36	398,18

As a conclusion, the results show that the tendency of the impedance patterns obtained by using respirometric techniques with Bactrac® system are concordant with the most common parameters used to monitor the composting process, such as the extracts of the different organic fractions. Therefore, this method is presented as a useful and effective tool for evaluating the progress of the composting process.

Keywords: Respirometry, composting, impedance, sewage sludg

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