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Electron transfer capacity as a rapid and simple maturity index for compost

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ABSTRACT

Electron transfer capacity (ETC) of dissolved organic matter (DOM) is proposed as the maturity index to predict the composting status, based on the fact that the compositions of DOM strongly associate with the degree of decomposition. ETC, including electron accept capacity (EAC) and electron recycle rate (ERR), increases as the composting goes on, showing a close correlationship with the germination index (GI). The correlation coefficient between EAC and GI is 0.9273, and that between ERR and GI is 0.9501. The measurements of these ETC parameters require no chemical reagent preparations before analyses and can be obtained very rapidly. The results of this study indicate that these simply and rapidly obtainable ETC parameters can be potential alternatives to evaluate the composting process.

1. Introduction

Waste organic materials produced by human activities, such as domestic refuse, crop straws, livestock wastes and municipal sludge, have been continuously accumulating. Composting as a low-investment process has been under intensive investigation in order to recycle these wastes as new materials or bio-resources (Sharma et al., 1997; Imbeah, 1998). The composting process can convert the waste organic materials to soil organic amendments known as compost. A critical point in the practical application to soils is the maturity degree of the compost because immature or fresh compost can cause phytotoxicity and contaminate the environment (Tian et al., 2012). Therefore, developing a simple and straightforward method to predict the composting status is important and deserves special attentions.

The maturity of composting is usually assessed using germination and plant growth tests (Warman, 1999), which, however, is usually a tedious undertaking because the germination index (GI) requires about 48–72 h to determine and involves complicated operations. Other parameters and methods have also been developed to evaluate the maturity of composting, including physicochemical and biological properties, such as carbon-to-nitrogen ratio (C/N), changes in nitrogen species, cation exchange capacity, optical density, thermogravimetry, Solvita tests, microbial respiration, microbial population changes, enzyme activities and more (Bernal et al., 1998; Chanyasak and Kubota, 1981; Herrman and Shann, 1993; Wang et al., 2004; Smith and Doran, 1996; Bernal et al., 2009). However, most of these approaches are either time-consuming or labor-intensive, or require expensive instruments.

Composting is a biochemical process by which part of the organic matter is eventually transformed into more stable and complex organic macromolecules (Hsu and Lo, 1999). Therefore, compost maturity has often been associated with the transformation of organic matters during the composting process (Jouraiphy et al., 2005; Wang et al., 2012). As the organic matter transform their properties change, such as the distribution of molecular weight, the structure of sub-components, the concentration of organic carbon and more (Chefetz et al., 1998; Zbytniewski and Buszewski, 2005). Thus, a number of maturity indices based on the property changes of organic matter have been proposed as well. For example, Tomati et al. (2000) suggested employing the humic acid molecular weight as an index of compost maturity. Amir et al. (2005) investigated the composting process of sewage sludge by characterizing the chemical structure of fulvic acids. Zmora-Nahum et al. (2005) found that the concentration of dissolved organic carbon (DOC) in compost was a simple and straightforward parameter for determining maturity, and recommended 4 g kg^{-1} as the threshold. For the same aforementioned reasons, however, these methods require to be simplified and improved before practical use. Previous studies have shown that DOM were redox active and capable of mediating biogeochemical redox reactions (Nurmi and Tratnyek, 2002; Huang et al., 2010). Evidence of their redox properties, including the reversibility of electron transfer from and to DOM and their electron accepting (EAC) and donating (EDC) capacities, has been previously

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