CHINESE JOURNAL OF ANALYTICAL CHEMISTRY
Volume 45, Issue 4, April 2017
Online English edition of the Chinese language journal

Available online at www.sciencedirect.com
ScienceDirect

Cite this article as: Chin J Anal Chem, 2017, 45(4), 579–586.

RESEARCH PAPER

Effect of Compositional and Structural Evolution of Size-fractionated Dissolved Organic Matter on Electron Transfer Capacity During Composting

YANG Chao[1,2,3], HE Xiao-Song[2,3,*], GAO Ru-Tai[2,3], XI Bei-Dou[1,2,3], HUANG Cai-Hong[2,3], ZHANG Hui[2,3], TAN Wen-Bing[2,3], LI Dan[2,3]

[1] School of Environmental and Municipal Engineering, Lanzhou Jiaotong University, Lanzhou 730070, China
[2] State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing 100012, China
[3] State Environmental Protection Key Laboratory of Simulation and Control of Groundwater Pollution, Chinese Research Academy of Environmental Science, Beijing 100012, China

Abstract: Ultrafiltration separation and spectrum analysis were employed to investigate the composition and structure evolution of size-fractionated dissolved organic matter (DOM) during chicken manure composting. Electrochemical method was applied to determine electron transfer capacity (ETC). The results showed that protein-like components, which were the main components at the initial stage of composting, were mainly observed in the DOM with molecule weight (MW) < 1 kDa. The protein-like components were persistently degraded during the composting process, whereas the humic-like components were persistently formed at the same time. The fulvic-like components became the main components at the end of composting process in instead of the protein-like components of DOM (MW < 1 kDa). The humic-like substances were the main fluorescence components of DOM with MW > 1 kDa. Though humic-like components with different molecular weight changed differently during composting, their content at the end of composting was higher than that at the initial of composting. Electron donating capacity (EDC) was persistently reduced during composting, whereas electron accepting capacity (EAC) of the DOM with the MW < 1 kDa was persistently increased during composting. The EDC of DOM with the MW > 1 kDa was persistently increasing during the composting process, though the EAC of the fraction showed no system change. There was on irregular for the ETC of the DOM with the MW of 1−3 kDa and 3−5 kDa. The EAC value of the size-fractionation DOM was controlled by the content of the aromatic carbon which was derived from lignin degradation, while the EDC value of these DOM did not showed obvious relation with the spectrum parameter.

Key Words: Composting; Dissolved organic matter; Molecular weight; Electron transfer capacity; Parallel factor analysis

1 Introduction

With the development of economy in China, the diet structure had changed dramatically. In the recent years, the consumption of meat and milk had been growing at a rate of about 10%[1]. Owing to the demand for livestock products, the animal husbandry industry became an important part of agricultural economy in China. However, the unreasonable treatment of aquaculture waste became one of the main sources of agricultural non-point source pollution[2]. Composting was applied as the main way for the treatment of livestock manure for its pollution-free and affordability[3,4]. Composting was a microbial treatment process. Organic matter was degraded into carbon dioxide or converted into

Received 11 October 2016; accepted 21 December 2016
*Corresponding author. Email: hexs82@126.com
This work was supported by the National Natural Science Funds for Distinguished Young Scholar of China (No. 51325804), and the National Natural Science Foundation of China (No. 51508540).

DOI: 10.1016/S1872-2040(17)61006-5

humic substance during the process[5]. Dissolved organic matter (DOM) was the most active part during organic matter conversion process. The aliphatics, polysaccharides, and proteins in DOM were used preferentially by microorganisms during composting, whereas the compounds with aromatic structural units in DOM existed stably and accumulated continuously during the process[6,7].

DOM was a heterogeneous mixture of organic compounds including organic acids, aliphatic, humic substance and protein[8,9]. Microorganism fed on DOM to maintain their vital activity. In addition, DOM influenced the migration and transformation of environmental pollutants through the absorption and reduction process[10,11]. Because of the redox ability of DOM, it enhanced electron transfer between microorganism and contaminant, resulting in the change of chemical species of the pollutant. Therefore, the electron transfer capacity (ETC) of DOM is an important environmental index. The mature composted product contained a low content of readily biodegradable substance and a high content of macromolecule[3,5,6], which could be applied to improve the properties of soil and accelerated pollutant transformation. Therefore, the research on the structural and constitute of the DOM and its influence on electron transfer capacity facilitated the use of composted product.

The different molecular weight (MW) of DOM played different important roles in the photochemical and biological reaction[12]. The previous report indicated that the DOM with the MW of below 1 kDa could be easily degraded by microorganism, but that with the MW of > 15 kDa remained stable during composting[13]. The structure, stability, humification degree and aromaticity of different molecular weight in DOM were different[14,15]. Romera-Castillo *et al*[16] found that the structural and fluorescent property of DOM was controlled by molecular weight. Some researcher found that, the organic matter was dominated by the DOM with the MW < 1 kDa at the beginning of composting, whereas the DOM with the MW > 25 kDa dominated in compost at the end of the process[17,18]. In addition, some of the small-molecular-size fraction of organic matter might be transformed into the large-molecular-size fraction during the composting process. ETC was controlled by component and structure of DOM, however the information on the influence of organic matter transformation on the ETC of DOM was limited.

Herein, five samples were collected at different stage of composting. DOM was obtained from the compost samples, and fractionated into four different molecular weight components using ultrafiltration technology, i.e., MW < 1 kDa, MW = 1–3 kDa, MW = 3–5 kDa and MW > 5 kDa. The ETC of the size-fractionated DOM were determined by electrochemical method. The composition and structure of the four DOM fractionations were studied by UV-vis and fluorescence spectrum. The aim of this study was to explore the change of ETC and its influenced factors during composting process.

2 Experimental

2.1 Instruments and reagents

Dissolved organic carbon content was measured by an Analytik Jena Multi N/C 2100 TOC analyzer (Analytik Jena, Germany). The fluorescence and UV-Vis spectra were measured using F-7000 luminescence spectrophotometer (Hitachi, Japan) and UV-1700 PC spectrophotometer (Shimadzu, Japan), respectively. Three ultrafiltration membranes with different molecular sizes (1, 3 and 5 kDa) were purchased from KOCH, USA. Electrochemical experiments were performed using an electrochemistry workstation CHI660E (Chenhua Co. Ltd, China) with a conventional three-electrode cell atan ambient temperature. 1,1'-Ethylene-2,2'-bipyridyldiylium dibromide (DQ) was purchased from the National Institute of Metrology, and 2,2'-azino-bis(3-ethylbenzothiazoline-sulfonicacid) (ABTS) was purchased from Shanghai Jun-chuan Technology Co. Ltd., China. The Mili-Q ultrapure water was used in this work.

2.2 Collection and treatment of composting sample

The fresh chicken manure was collected from the chicken farm located in Changping district, Beijing. Chicken manure, saw-dust and hay were mixed in barrel static composting equipment which had the height of 400 mm and the width of 330 mm. The ratio of three substances for the mixture was 6:2:1, the C/N ratio of the mixture was 26, and its moisture content was in the range of 50%−60%[19]. The temperature of the reactor increased rapidly from 25 °C to 50 °C during the first three days, and reached to the highest temperature of 63 °C after four days of composting. The temperature gradually decreased from the 7th day, and was the same to the outdoor temperature at 16th day of composting. The pile was turned and its humidity was maintained at around 50%–65% with the addition of composting leachate. Five composts were sampled after 1, 8, 16, 28 and 40 days of composting, and each of them was collected from three different heights and then mix evenly. The samples were freeze-dried under –55 °C, then through the 100 mesh screen after fully grind.

2.3 Extraction of DOM

The samples were extracted using ultrapure water with the ratio of 1:10 (*w/V*), and then shaken for 24 h in a horizontal shaker at room temperature. The extracts were centrifuged at 12000 rpm for 20 min and filtered through a 0.45-μm membrane filter.

DOM was separated into four different molecular weight components by ultrafiltration membranes with three pore diameters[20,21], i.e., MW < 1 kDa, MW = 1–3 kDa, MW = 3–5 kDa and MW > 5 kDa. The dissolved organic carbon content