Science of the Total Environment 621 (2018) 417–424

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Application of microwave-pretreated cephalosporin mycelial dreg (CMD) as soil amendment: Temporal changes in chemical and fluorescent parameters of soil organic matter

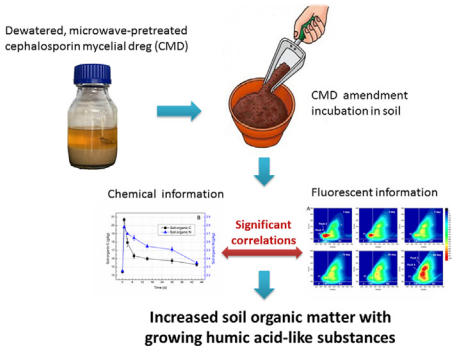
Chen Cai, Huiling Liu *

State Key Laboratory of Urban Water Resource and Environment, School of Environment, Harbin Institute of Technology, Harbin 150090, China

HIGHLIGHTS

- The microwave-pretreated CMD was utilized as a soil amendment with high efficacy.
- The SOM content increased at the end of the incubation period.
- A shift in fluorescent composition and an elevated $P_{V,n}/P_{III,n}$ index were observed.
- The stabilization phase could be clearly differentiated using PCoA.
- FRI data significantly correlated with chemical parameters ($M^2 = 0.2875$, $r = 0.8441$).

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 15 August 2017
Received in revised form 14 October 2017
Accepted 22 November 2017
Available online xxxx

Editor: Ajit Sarmah

Keywords:
Cephalosporin mycelial dreg (CMD)
Amendment
Soil organic matter (SOM)
Excitation-emission matrix spectra (EEM)

ABSTRACT

Land application of treated cephalosporin mycelial dreg (CMD) as a soil amendment is an alternative to its disposal in landfills and incineration because it has environmental and agronomic benefits. This study validated the efficacy of using the dewatered, microwave-pretreated CMD as a soil amendment. Pot experiments were conducted to assess the temporal changes in soil organic matter (SOM) profiles via chemical and fluorescent parameters. During the ageing period, the CMD-treated soil experienced a sudden rise in soil pH and soil electrical conductivity, along with a rapid decline in soil organic carbon and soil organic nitrogen content. The specific Ex/Em peak related to protein-like substances gradually disappeared, while those related to humic acid-like substances continued to increase thereafter. Fluorescence regional integration (FRI) results showed an ascended $P_{V,n}/P_{III,n}$ index (1.94) and significant correlations with chemical data ($M^2 = 0.2875$, $r = 0.8441$, $P < 0.001$, 999 permutations for Procrustes analysis). Taken together, despite the temporal changes in chemical and fluorescent data after soil conditioning, the increased content of SOM containing humic acid-like substances was observed at the end of the incubation period compared with control soil samples, indicating that the microwave-pretreated CMD might be applied as a soil amendment.

1. Introduction

The consumption of the top seven antibiotic classes has been estimated to annual 70 billion individual doses on earth since 2010 (Blaser, 2016). China has ranked first in the world in production and

* Corresponding author at: State Key Laboratory of Urban Water Resource and Environment, School of Environment, Harbin Institute of Technology, Harbin 150090, China.
E-mail address: hlliu2002@163.com (H. Liu).

https://doi.org/10.1016/j.scitotenv.2017.11.261
0048-9697/

Table 1
Characteristics of the soil and experimental organic amendment (CMD).

Dewatered and microwave-pretreated CMD		Soil	
Parameters	Value	Parameters	Value
pH	5.5 ± 0.2	pH	7.6 ± 0.1
Water content (wt%)	33.3 ± 0.2	SOM (%)	7.1 ± 0.1
Total C (g/kg)	301.5 ± 10.3	EC (μS/cm)	162.4 ± 2.3
Total N (g/kg)	51.3 ± 1.2	SOC (g/kg)	14.4 ± 0.4
CPC (g/kg)	Not detected	SON (g/kg)	2.3 ± 0.2

CPC: cephalosporin C; SOM: soil organic matter; EC: soil electrical conductivity; SOC: soil organic carbon; SON: soil organic nitrogen.

export of bulk antibiotics, generating approximately 1.4 million tonnes of bio-ferment residue each year (according to the ratio of 1 tonne of antibiotic producing 8–10 tonnes of bio-ferment residue) (Li et al., 2012). Cephalosporin mycelia dreg (CMD) is one kind of bio-ferment residue with over 50% of the total production. It is the precipitation of fermentation broth for producing cephalosporin C (CPC), a bulk drug for synthesizing various categories of cephalosporins. In 2008, CMD was added into the list of national hazardous waste category under HW02-276-001-02 code (Jiang et al., 2012) due to the residual antibiotics (i.e., CPC in this study) that are suspected to be an important contributor in the potential development of antibiotic-resistant genes (Zhu et al., 2013; Bondarczuk et al., 2016). Since then, the disposal problem of this massive biowaste has been heavily perplexing the biopharmaceutical industry. Considering the high organic matter content (up to 90% based on dry weight) such as proteins and carbohydrates, converting CMD into a raw material for producing a soil amendment has drawn more attention and is possible, as long as immediate and proper treatments are effectively implemented for these biowastes (Zhang et al., 2015; Zhang et al., 2016a). Microwave treatment, an alternative of various disposals, was developed during our previous work (Cai et al., 2017). This treatment effectively disintegrated CMD and

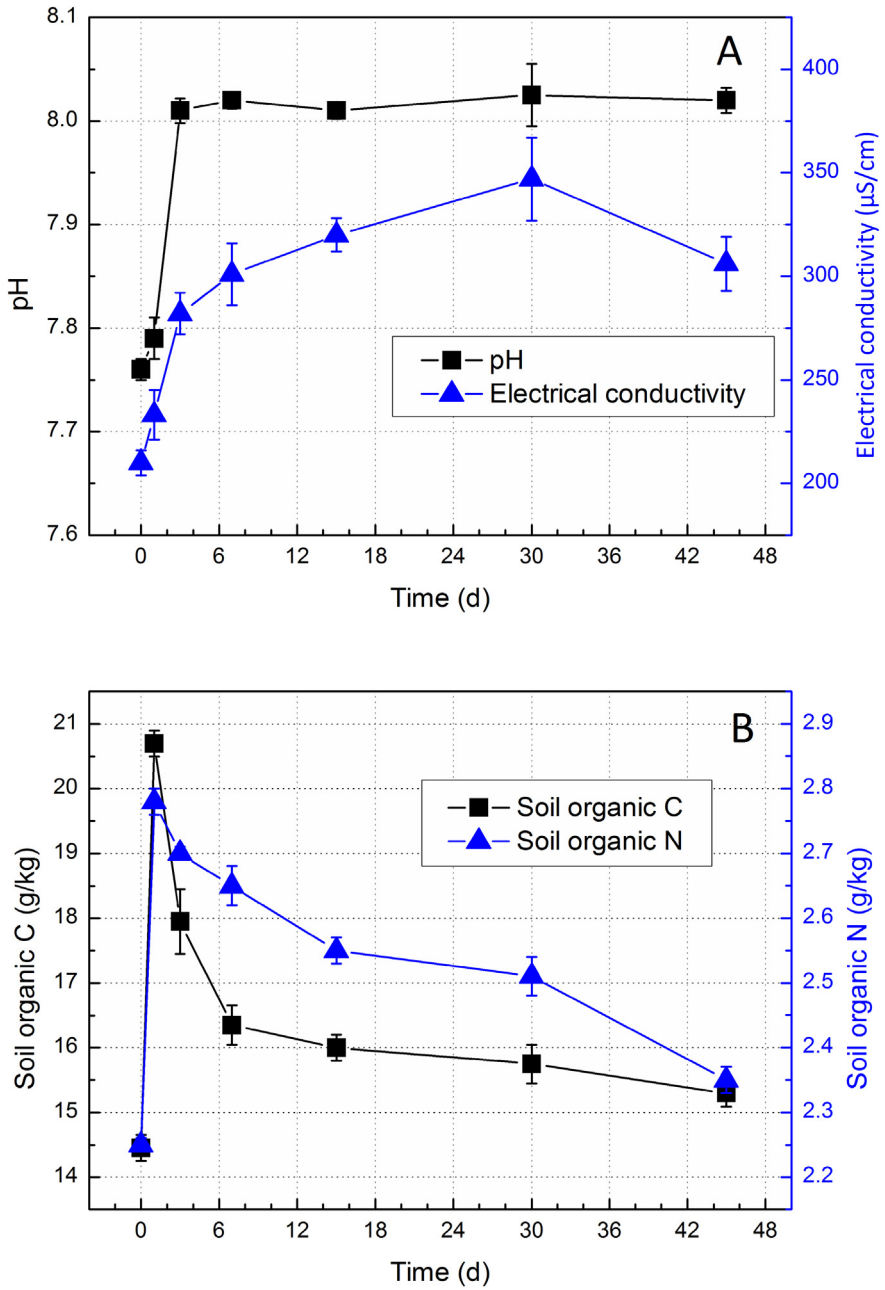


Fig. 1. Changes in chemical parameters detected during CMD amending. (A) pH and electrical conductivity of soil solution. (B) Soil organic C and soil organic N.