Waste Management xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

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

Evaluation of the antibiotics effects on the physical and chemical parameters during the co-composting of sewage sludge with palm wastes in a bioreactor

Amine Ezzariai [a,b,c], Maialen Barret [b,c], Georges Merlina [b,c], Eric Pinelli [b,c], Mohamed Hafidi [a,*]

[a] Laboratoire Ecologie et Environnement (Unité associée au CNRST, URAC 32), Faculté des Sciences Semlalia, Université Cadi Ayyad, BP 2390 Marrakech, Morocco
[b] Laboratoire Ecologie Fonctionnelle, Université de Toulouse, UPS, INP, EcoLab, ENSAT, Avenue de l'Agrobiopôle, F-31326 Castanet-Tolosan, France
[c] CNRS, EcoLab (Laboratoire d'écologie fonctionnelle et environnement), F-31326 Castanet-Tolosan, France

ARTICLE INFO

Article history:
Received 29 January 2017
Revised 19 June 2017
Accepted 20 June 2017
Available online xxxx

Keywords:
Antibiotics
Sewage sludge
Palm wastes
Bioreactor co-composting
Microbiological approach

ABSTRACT

The objective of this study was to investigate thermal and physicochemical parameters of sewage sludge-palm waste mixtures contaminated by different families of antibiotics (tetracyclines, macrolides and fluoroquinolones) during co-composting. Sludge was spiked with chlortetracycline (CTC), oxytetracycline (OTC), roxithromycin (RXY), enrofloxacin (ENR) and ciprofloxacin (CIP). Antibiotics were spiked at a low level, medium level, high level and a control without antibiotics was conducted. The results showed that the organic matter degradation was delayed and the carbon/nitrogen (C/N) ratio was affected by an increase of the antibiotics concentration. The presence of antibiotics, especially at high level, delayed the coming of the temperature maxima, and disturbed the thermophilic phase. The calorific model showed that the heat release is affected during the thermophilic phase when high antibiotics concentrations were used. In addition, the microbiological approach showed that the adsorption of antibiotics on the rachis could be probably responsible of the fungi inhibition especially during the maturation phase. Therefore, the medium and high levels of antibiotics affected the thermal, physical and chemical parameters as well as the compost quality.

1. Introduction

The annual use of antibiotics is estimated to be between 100,000 t and 200,000 t worldwide (Jeong et al., 2010). In the United States, 16,000 t of antimicrobial compounds are used annually, 70% of them are used for non-therapeutic purposes (UCS, 2001). Although, 2/3 of antibiotics are used in human medicine and 1/3 are used for veterinary purposes in the Europeans countries (Sarmah et al., 2006). For Morocco, the consumption per family of antibiotics was evaluated statistically for human use over a period of ten years (Inouss et al., 2015). The use of antibiotics for human health purpose (domestic and hospital) leads to their continuous release into the environment via different sources, such as the waste water treatment plants (WWTP). Several researches confirm the persistence of antibiotics in the WWTP which can be considered as an anthropogenic source for contamination by antibiotics (Rizzo et al., 2013). WWTP include different processes which are regarded as limiting for antibiotics elimination (Mao et al., 2015; Polesel et al., 2016). So, a part of these molecules are discharged in the environment with the out coming of treated water and the other part is fixed to the sludge process (Michael et al., 2012; Xu et al., 2015). Several studies were reported that the antibiotics concentrations can range of µg/kg to a few mg/kg in sludge (Golet et al., 2002; Martín et al., 2014; Verlicchi and Zambello, 2015) and their direct application is a source of antibiotics emergence in the environment. The wide occurrence of antibiotics in the environment can affect the aquatic and terrestrial organisms even at low concentrations of a mixture of antibiotics (Khadra et al., 2012), alter the microbial activity and the microbial community composition, and can also lead to the prevalence of a bacterial resistance to antibiotics (Zhou et al., 2013). Composting is a natural process for organic matter conversion by microorganisms under aerobic conditions and leads to a stable and hygienic fertilizer which can be reused for improving the quantity of humic substances and increasing the aromatization degree in the soil (Amir et al., 2010). Composting is an effective solution to reduce the highest produced quantities of a several type of waste such as palm waste and sludge. For example, the palm groves of Marrakech city in Morocco generate a significant amount of palm

* Corresponding author.
E-mail address: hafidi.ucam@gmail.com (M. Hafidi).

http://dx.doi.org/10.1016/j.wasman.2017.06.036
0956-053X/

waste products. According to the environmental services of the urban commune of Marrakech, the palm waste generated is about 8000 tons per year (El Fels, 2014). In the other hand, The WWTP of Marrakech produces actually 50,400 kg/d of primary sludge and 89,600 kg/d of secondary sludge (Belloulid et al., 2016).

Although the fate of antibiotics during co-composting has been investigated (Arikan et al., 2009; Selvam et al., 2012a, 2012b; Ho et al., 2013; Liu et al., 2015), but little information is given in the literature about the influence of antibiotics on the thermal and physicochemical parameters during the sludge co-composting process in controlled conditions. The objectives of this study were (i) to optimize and control the operating parameters of a co-composting bioreactor, (ii) to evaluate the effect of some antibiotics at different concentrations on the thermal, physical and chemical parameters during the co-composting process, (iii) to present a microbiological approach concerning the interactions mechanisms between the antibiotics and the substrates used for the co-composting process and more particularly the lignocellulosic one, and finally (iv) to approach an effective antibiotic concentration that is enables or not to influence the co-composting process and alters or not the compost quality.

2. Materials and methods

2.1. Bioreactor description and its operating conditions

The co-composting experiments were conducted in the bioreactor described by Viel et al. (1987) with some modifications (Fig. 1). The bioreactor is a cylindrical tank in stainless steel (100 L), surrounded by a 8 cm polyurethane insulating. The tank has been fixed on a swivel stand in order to simplify the handling and the compost loading. The bioreactor is composed of a circular waterproof cover with a hole for samples collection. The fresh air, coming out from a compressor, was injected inside the bioreactor with a constant flow under the control of a rotameter, the compost mixing was conducted by a programed system, the temperature of compost was measured at the three points inside the bioreactor, the exhaust gas was trapped in a concentrated sulfuric acid solution, the condensed water was recovered at the top of the bioreactor and a biological filter was used to trap the upsetting odors. After 12 days of stabilization in the bioreactor, this stage of compost was transferred into the perforated bag to conduct the maturation stage for 6 month.

2.2. Bioreactor optimization and the retained co-composting substrates

Optimization experiments were conducted in order to control the operating parameters of the bioreactor and to choose the good mixture composition in view to perform a reference experiment which could allow the better organic matter degradation and offer the maximum loading of sludge during the co-composting process. 3 substrates of co-composting have been used during the optimization experiments. The palm wastes (palm rachis and leaves separate) and the grass were collected from the Faculty of Science-Marrakech (Morocco). The primary (non-treated) and secondary (biological) sludges were collected from the WWTP of Marrakech. The experiments with secondary sludge were conducted for having a comparison with the primary sludge which was finally retained for the antibiotic co-composting experiment. Table 1 presents the physical and chemical characteristics of the substrates used during all optimization experiments, and Table 2 presents the percentage of each substrate used during the 5 experiments of co-composting (E1–E5) conducted to optimize the bioreactor.

2.3. Antibiotics

The Tetracyclines (chlortetracycline hydrochloride (75% of purity) and oxytetracycline hydrochloride (95%)), a Macrolides

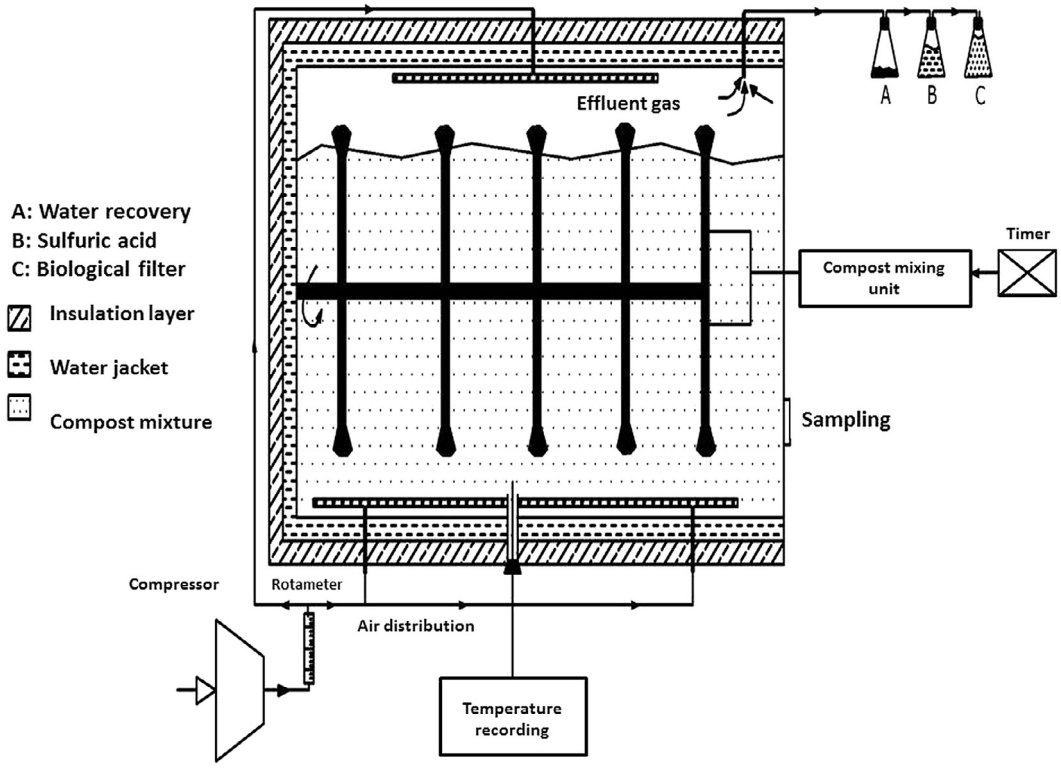

Fig. 1. Co-composting bioreactor.

Please cite this article in press as: Ezzariai, A., et al. Evaluation of the antibiotics effects on the physical and chemical parameters during the co-composting of sewage sludge with palm wastes in a bioreactor. Waste Management (2017), http://dx.doi.org/10.1016/j.wasman.2017.06.036