Ecological Engineering 110 (2018) 165–171

Contents lists available at ScienceDirect

Ecological Engineering

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

Research Paper

Effect of organic loading rates on biogas production and anaerobic biodegradation of composting leachate in the anaerobic series bioreactors

Hadi Eslami[a,1], Hassan Hashemi[b,1], Reza Ali Fallahzadeh[c,1], Rasoul Khosravi[d,1], Reza Fouladi Fard[e,1], Ali Asghar Ebrahimi[c,*,1]

[a] Department of Environmental Health Engineering, School of Health, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[b] Research Center for Health Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[c] Environmental Science and Technology Research Center, Department of Environmental Health Engineering, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[d] Social Determinants of Health Research Center,Department of Environmental Health Engineering, School of Health, Birjand University of Medical Sciences, Birjand, Iran
[e] Research Center for Environmental Pollutants, Qom University of Medical Sciences, Qom, Iran

ARTICLE INFO

Keywords:
Biogas production
Leachate treatment
Anaerobic biodegradation
Composting leachate
Organic loading rate

ABSTRACT

This study investigated the biodegradability of composting leachate and biogas production in different Organic Loading Rates (OLRs) in lab-scale series AMBR-ASBR bioreactors, Anaerobic Migrating Blanket Reactor (AMBR) and Anaerobic Sequencing Batch Reactor (ASBR). The raw Leachate with OLRs of 1.04–19.65 gCOD/L.d went into the AMBR reactor and then into the ASBR reactor with hydraulic retention time of 24 h. The produced methane and biogas were measured by GC-TCD and gas meter. The results showed that the best removal efficiency for BOD_5, COD and readily biodegradable COD (rbCOD) in AMBR-ASBR hybrid reactor were 99.43%, 97.35% and 99.79%, respectively. The maximum amounts of biogas and methane production were 16.37 and 9.99 L in OLR of 10.08 gCOD/L.d. With the increase in OLRs, biogas production also increased, but in higher OLRs (18.52 gCOD/L.d) with a sudden increase in OLR, methane and biogas production decreased. Moreover, the ratio of the biogas production to inlet COD was 1.35 L (R^2 = 0.994), that is equal to the ratio of produced biogas (L) to inlet Volatile Suspended Solids (VSS) (g) (R^2 = 0.972). Thus, considering OLRs effects, it was observed that the AMBR-ASBR hybrid reactor as a novel series system could be remarkably efficient in compost leachate treatment and increasing biogas production.

1. Introduction

In recent years, the production of compost from organic solid wastes has been widely considered and the main concern in the composting process has been the produced leachate (Amin and Moazzam, 2014; El-Gohary and Kamel, 2016; Hashemi et al., 2016; Taiwo, 2011). The leachate composition from the solid waste is very different from one place to another and depends on the composition of solid waste, hydrological conditions and the operation of disposal facilities, and climatic conditions(Kurniawan et al., 2006). In general, the composting process leachate contains high amounts of organic and inorganic pollutants (high concentration of COD and BOD_5), ammonium, pathogenic organisms, and hazardous and toxic chemicals (such as heavy metals and phenolic/aromatic compounds) (Chen et al., 2008; Deng and Englehardt, 2006; Ghaly et al., 2007). As a result, leachate can be a source of soil, surface water, and ground water contamination, and hence it can be a threat to the human health and environment (Bakhshoodeh et al., 2017; Renou et al., 2008; Zhang et al., 2007). Thus, the proper management and treatment of composting Leachate, particularly in the use of biological methods, has been highly regarded by researchers (Aziz et al., 2010; Eslami et al., 2017; Khosravi et al., 2013; Qi et al., 2012; Salem et al., 2008; Shahi et al., 2013).

Among the biological methods, anaerobic methods have great importance due to the high amounts of organic substances in leachate and the production of clean biogas fuel (Khalid et al., 2011; Shooshtari et al., 2012; Wu et al., 2015). According to the reduction of fossil fuels and their pollution, biogas technology can be used as a source of renewable and eco-friendly energy (Adanikin et al., 2017; Mahar et al., 2016; Minde et al., 2013). Anaerobic treatment of composting leachate causes the conversion of organic compounds to biogas containing CH_4 and CO_2 and forming a biological sludge (Amin et al., 2014). At least 20 percent of the needed energy in the EU comes from renewable energy

* Corresponding author.
E-mail addresses: hadieslami1986@yahoo.com (H. Eslami), hashemi@sums.ac.ir (H. Hashemi), fallahzadeh4@yahoo.com (R.A. Fallahzadeh), khosravi.r89@gmail.com (R. Khosravi), ebrahimi20007@gmail.com, ebrahimi20007@ssu.ac.ir (A.A. Ebrahimi).
[1] All Authors Field Study: Environmental Health Engineering.

https://doi.org/10.1016/j.ecoleng.2017.11.007
Received 20 July 2017; Received in revised form 11 September 2017; Accepted 13 November 2017
Available online 20 November 2017
0925-8574/

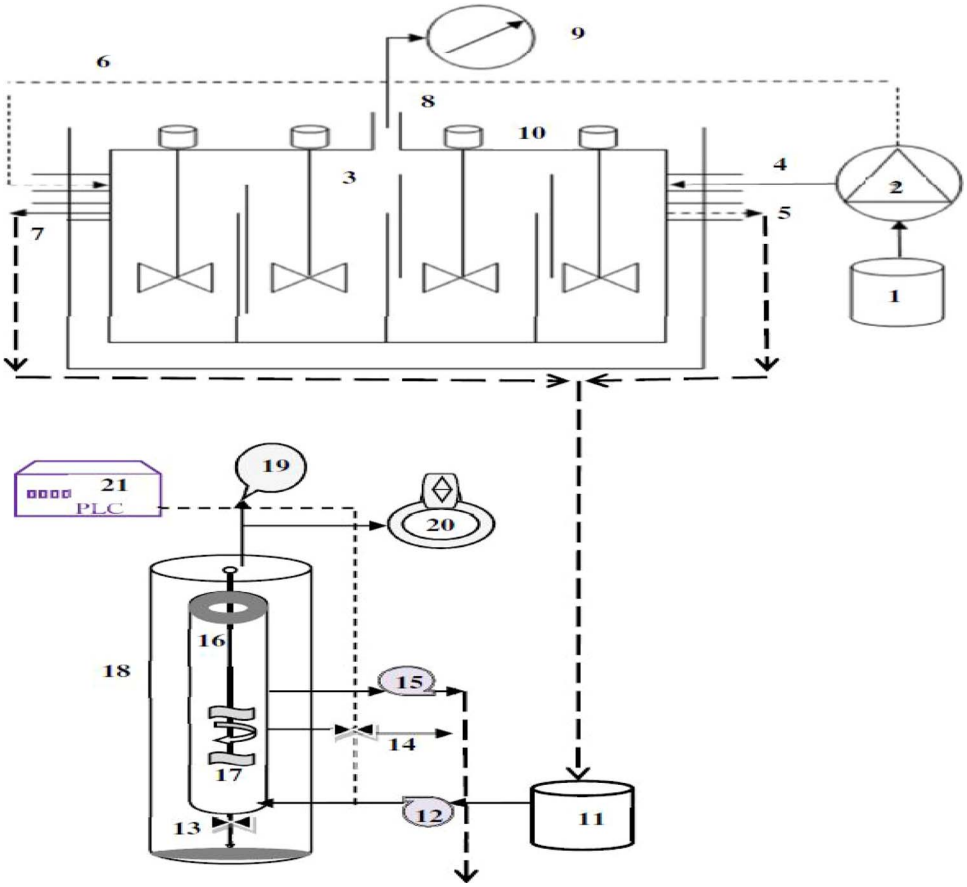

Fig. 1. Simplified schematic diagram of the AMBR-ASBR series reactors.
(1- feeding tank for AMBR, 2-Injection Pump, 3-AMBR Reactor, 4 and 6–Influents, 5 and 7- Effluents, 8-Biogas Output, 9-Gas Meter, 10- Mixers, 11-feeding tank for ASBR, 12-injection pump, 13-sludge intake valve, 14-sampling valve, 15-decant valve, 16-ASBR Reactor, 17-mixer, 18-bath container water, 19-Tedlar bag, 20-gas meter and 21-PLC)

and 10 percent of the transport fuels is biofuel (Ghani and Idris, 2009).According to the amount of volatile solids, C/N ratio, and the amounts of biodegradable materials in composting leachate, the anaerobic digestion method can be used for treatment and production of biogas (Hashemi et al., 2015b). Among the anaerobic leachate treatment methods, the Anaerobic Migrating Blanket Reactor (AMBR) system is considered as an anaerobic system with a high load, continuous flow, short hydraulic retention time, and simple design (Kuşçu and Sponza, 2009). Because of the slow mechanical mixing in the reactor, sewage with large volumes of active biomass can have excellent contacts (Krishna et al., 2009). The main advantage of this type of reactor is its stability to sudden hydraulic and organic loads due to the reactor's chamber building, low production of sludge, no need for gas and solid separation devices, low operating costs, higher toxicity tolerance, pH, and temperature changes (Kuscu and Sponza, 2007). In the AMBR reactor, the first chamber plays an important role in the growth of methane construction bacteria in the next chambers, because toxic substances or changes in environmental conditions such as pH and temperature are balanced in the first chamber; as a result, the bacteria can grow and reproduce in the next chambers (Kuşçu and Sponza, 2009). Previous studies have shown that the amounts of Organic Loading Rate (OLR) and methane in the AMBR reactor have been more than the amounts in UASB and ASBR reactors (Ebrahimi et al., 2015). Another anaerobic treatment processes is Anaerobic sequencing batch reactor (ASBR) with the following advantages: high flexibility of the system, the proper control of microbial population due to cyclic or intermittent operating conditions, and isolation of microbial retention time from the hydraulic retention time (Hashemi et al., 2015a; Ma et al., 2013). In a study on the effects of the ASBR process on leachate treatment, about 85% of the organic matters were converted to methane (Hashemi et al., 2015a).

Accordingly, in the current study, the biodegradability of composting leachate and biogas production in different OLRs were investigated in lab-scale series AMBR-ASBR bioreactors.

2. Material and methods

2.1. Experimental procedure

A lab-scale experimental setup study for leachate treatment and biogas production in different OLRs was conducted in AMBR-ASBR anaerobic combined bioreactors. The inlet leachate of ponds in Isfahan composting plant was used for sampling. After analyzing the quality of raw leachate, in the first pH of leachate regulated by Sodium hydroxide (2N) and depending on the concentration of inlet leachate, leachate of the composting plant was diluted and injected into the AMBR reactor by a peristaltic pump (Etatron Co, Italy), with a minimum OLR of 1.04 gCOD/L.d a flow rate of 1 L per day. This flow rate entered the ASBR reactor over a period of 24 h. It should be noted that for convenient and accurate steering and controlling of used pumps and mixers in AMBR reactor, an electronic processor, known as programmable logic controller (PLC), from a Japanese company (Omron) was used. After the analyzing of the COD:N:P ratio in raw leachate, essential macronutrient for the biological activity of anaerobic reactors, ammonium chloride (NH_4CL), and potassium dihydrogen phosphate (KH_2PO_4) was employed to provide required nitrogen and phosphorus for the reactor. For initial seeding, the sludge from anaerobic digester of a wastewater treatment plant in the north of Isfahan was used. Loading the reactor with diluted leachate lasted to 8 cycles of operation and in the 9th cycle, the real leachate entered the reactor without dilution, in periods of 10 and 11 cycles. By doubling inlet flow rate and increasing the organic loading rate, the reactor performance was evaluated.