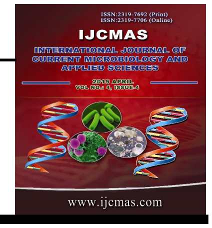

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Review Article

A review on optimization of parameters for vegetable waste biomethanation

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A B S T R A C T

Vegetable markets and kitchen generates huge quantity of vegetable waste per day. The vegetable wastes are voluminous and perishable. Unscientific disposal methods cause an adverse impact on all components of the environment and human health. Biomethanation is the anaerobic digestion of biodegradable organic waste under controlled conditions of temperature, moisture and pH in an enclosed space to generate biogas comprising mainly methane and carbon dioxide. The main biochemical reactions involved in biomethanation are hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis. Methane, a source of renewable energy can be converted into electricity and effluent from biomethanation plant can be used as soil conditioner. Thus, biomethanation, a biological treatment process appears to be an economically viable option for the treatment of vegetable wastes. The aim of this review paper is to present the detailed studies on biomethanation of vegetable wastes.

Keywords

Vegetable waste, environmental pollution, biomethanation, renewable energy, etc.

Introduction

Vegetable waste are a type of biomass where energy is stored in the form of carbohydrates, proteins and fat which may be converted into any other form of energy through thermo chemical conversion or biochemical conversion process. Vegetable waste is produced in large quantities during harvesting, poor and inadequate transportation, storage facilities and marketing practices.

Vegetable wastes are responsible for great amount of environmental pollution (Rathi, 2006; Diaz et al., 2007; Zhu et al. 2008). Uncontrolled dumping in municipal landfills and spreading on land bears several adverse consequences such as land, water and air pollution (Kumar et al., 2001, Kumar et al. 2009). In addition it emits methane, a major green house gas contributing to global warming. It further promotes the breeding of flies, mosquitoes, rats and other disease vectors at the disposal site (Zurbrügg, 2002). These unscientific disposal methods result in loss of potentially valuable materials that can be processed to generate fuel and fertilizer (Baffi et al., 2005).

The collection, transportation and disposal of vegetable waste is a very serious problem today. Land filling treatment method is not suitable because for most of the cities, space is a constraint. In other treatment methods like incineration and pyrolysis, air pollution problems are predominant and initial investments are also too high. The most promising alternative to these methods and composting is biomethanation, which has received increasing attention in recent years.

There are several factors which affect the performance of vegetable waste biomethanation process. Thus the present review paper was undertaken to focus onto the detailed aspects on optimization of operational and environmental parameters for biomethanation of vegetable wastes.

Optimization of operational and environmental parameters for biomethanation of vegetable waste

Hydraulic retention time (HRT)

The amount of time the feedstock stays in the digester is known as hydraulic retention time. The retention time must be sufficient to carry out the necessary degree of biodegradation. Shorter retention time have the risk of washout of active bacterial population while longer retention time requires a large volume of the digester and hence more capital cost. The appropriate time depends on the type of feedstock, environmental conditions and intended use of the digested material (Ostrem and Themelis 2004).

Biomethanation of vegetable wastes has been carried out at different HRT by several researchers. HRT 15 days (Das and Mondal,2013; Mondal and Biswas,2012;Islam et al,2009;Davidsson et al,2007), 14-18 days(Hartmenn and Ahring,2005),10-12 days(Bouallagui et al,2009; Kim et al,2006; Kale and Mehetre,2006;), 20 days (Liu et al,2012;Chen et al,2008;Ranade et al,1987;Bouallagui et al,2003), 21 days (Callaghan et al, 2002), 25 days (Dhanalakshmi et al,2012; Babee and Shayegan,2011; Sunil kumar et al,2010; Elango et al,2006), 30days (Velmurugan and Ramanujan, 2011;Alvarez et al,2008; Panyue Z et al,2008;Kulgarz and Mrowiec,2008), 40 days (Ojolo et al,2008), 60 days (Selina and Joseph,2007) and 100 days (Rao and Singh,2004) have been reported.

Organic loading rate (OLR)

The organic loading rate (OLR) determines the input of organic matter per unit volume of digester capacity per day expressed as mass of organic matter over digester volume over time. There is an optimum feed rate for a particular size of plant, which will produce maximum gas and beyond which further increase in the quantity of substrate will not proportionately produce more gas. Different OLR have been used to feed the reactors by researchers. Dhanalakshmi et al (2012) obtained the biogas yield 0.423 L/gm VS and 0.576 L/gm VS for two OLR of 0.25 and 0.50 gm VS/L.d respectively. Dhanalakshmi and Ramanujan (2012) used OLR of 0.06-0.47 gm VS/L.d in experiment. Maximum cumulative gas was produced at OLR 0.26 gm VS/L.d.

Temperature

Temperature is an important parameter for biomethanation. Many researchers have reported the significant effects of temperature on biomethanation kinetics, and stability (Boe, 2006; Kim et al., 2006; Lindorfer et al.,2008; Bouallagui et al., 2009; Fezzani and Cheikh, 2010; Riau et al., 2010). Temperature has significant effect on the microbial community, process kinetics and stability and methane yield (Bouallagui et al., 2009; Riau et al., 2010). Methane producers are generally more sensitive to temperature fluctuations than other microorganisms in the process. It is reported that biomethanation of biomass can take place in three different ranges: pychrophilic (<20°C), mesophilic (20-40°C) and thermophilic (40-68°C). The most common temperature ranges used to run anaerobic reactors are either mesophilic or thermophilic.

Biomethanation of vegetable waste has been carried out in mesophilic conditions (Dhanalakshmi et al, 2012; Dhanalakshmi and Ramanujan, 2012; Babee and Shayegan, 2011; Alvarez et al, 2008; Bouallagui et al, 2003; Callaghan et al, 2002). Biomethanation at ambient temperature conditions (25-37^{0}C) have been studied by many workers (Das and Mondal, 2013; Lama et al, 2012; Velmurugan and Ramanujan, 2012; Cahyari and Putra, 2010; Kulgarz and Mrowiec, 2010; Islam et al, 2009; Alvarez and Liden, 2008; Chen et al, 2008; Ojolo et al, 2008; Selina and Joseph,2007; Elango et al,2006; Kumar et al,2006). Rao and Singh (2004) carried out vegetable waste biomethanation at room temperature (25^{0}C) and ambient temperature (29^{0}C).

pH

pH is an important parameter affecting the growth of microbes during biomethanation. The optimum pH and pH range differs with substrate and biomethanation technique (Liu et al., 2007). The range of acceptable pH for organisms involved in biomethanation is 5.5-8.5(Kapdan and Kargi,2006; Poliafico, 2007; Drapcho et al., 2008; Park et al., 2008; Lee et al., 2009). Methanogenic bacteria are very sensitive to acidic conditions and their growth and methane production are inhibited in acidic environment. The optimum pH and pH range will vary with substrate and digestion technique (Liu et al. 2007). The pH values that are found to be optimal for biomethanation of mixture of vegetable wastes are 6.7-5.48 (Lama et al,2012), 6.8 (Biswas et al,2007; Biswas et al,2006), 6.8-7.3 (Elango et al,2006), 6.9(Mondal and Biswas,2012), 6.9-7.0 (Dhanalakshmi et ai,2012), 7.0 (Selina and Joseph,2007), 7.0-7.5 (Cahyari and Putra,2010) and 7.5 (Velmurugan and Ramanujan,2011; Kumar et al,2006).

In conclusion, the biomethanation process depends on the composition of substrate. Vegetable wastes, due to their high carbohydrate content (Suthar et al., 2005), biodegradability nature (Misi et al, 2002) and high moisture content are a good substrate for the production of biogas through biomethanation process. Biomethanation of vegetable wastes has been carried out at different HRTs as 15-100 days but the optimal HRT for biogas production is found to be between 20-30 days. The optimal temperature for biomethanation studies used by several workers is found to be at mesophilic conditions. The pH 7.0 is found to be optimal for vegetable waste biomethanation studies.

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