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A review on current aspects and diverse prospects for enhancing biogas production in sustainable means

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ABSTRACT

A key strategy allied with today is to develop an alternative energy source instead of fossil fuels in order to compensate present energy need in addition to reduce environmental concerns owed by pollution and global warming. Energy generation in feasible manner without possessing environmental crash is a difficult task where alternative concepts were requisite to ensure sustainable development with accessible technologies. Further advances triggered renewed attention in biogas production technology while it has great impacts on diminishing major economic issues raised in the world. Since the light of these strategies, the present review intended to critically evaluate the recent technological advances and promising prospects coupled with various aspects of biogas production such as sustainable feedstock utilization, microbial and enzyme dynamics, parameter optimization and process segregation, for enhancing this technology in outlook. Appropriate selection, co-digestion, and biotransformation offers a great challenge that crafts substrate to become more energy efficient, besides to trim down the constraints behind principle biomass utilization. A basic framework for process stimulation with microorganisms and enzyme preparations explored that further experimental trials by means of identification of efficient microbes and standardization of enzyme dynamics would augment the feasibility of energy flow during anaerobic digestion. Accordingly, the optimization of various parameters is preferred to accelerate biogas production by resolving the problems occur during anaerobic digestion. Despite the development of multi-stage digester designs intend a breakthrough for process segregation and existing opportunities in this aspect needed further research interest to attain better performance of the system. Moreover, advance simulation approaches using projected prospects from this review would realize significant enhancement of biogas production in the predictable manner.

Contents

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1. Introduction

The energy sector is the most significant area at present; gather round deprivation of energy due to the depletion of the traditional energy source fossil fuels. Global energy demand, environmental concerns with the accidental discharge of fossil fuels and greenhouse gas emission contribute towards the requirement of an alternative option for energy generation that makes economic wellbeing. Biofuel technology has been under consideration for past few decades where the production of biogas as an alternative energy source to fossil fuels is anticipated to grow at a huge range [1]. Biogas production with the evolution of flammable gas methane has been attracted promisingly since its lower production cost and environmental impacts over the residual biofuels recognized. However, industrialization of biogas production technology has been on track from 1950 whereas its economic production attained more interest due to the energy crisis turn out during 1973 and 1979. Around 50–80% failure rate was depicted in most of the countries take in India, China, Thailand, Europe, Africa and Russia throughout the concern period, even as a modest success rate for farm digesters were observed in the following years through extensive government banking and societal pressure [2]. The World Energy Council accounted that energy utilization will be increased many fold in the upcoming scenarios. According to the Kyoto protocol, renewable electricity production has been consequently elevated from 1997 to 2008 that could implement renewable energy sources having high energy potential for biogas production in Worldwide. As well the International Panel on Climate change (IPCC) has put forward an assertion that a threefold increase in energy consumption would happen by 2100 whilst probable improved energy generation from biomass is intended as 50000 TWh in 2050, 75000TWh in 2075 and 89000 TWh in 2100 [3,4]. However, the present thirst for energy production enforces further research and development in various aspects of the biogas production process that will be pleasing for commercialization of biogas until 2020.

Anaerobic digestion is a collection of processes by which relevant bacteria convert biodegradable organic materials into biogas under anaerobic circumstances through four different stages- hydrolysis, acidogenesis, acetogenesis and methanogenesis. Biogas production technology for energy conception offers a great challenge at present and expand further opportunity in future once acquire more efforts in this area. Multiple benefits undertaken by the biogas production process is it offers alternative fuel, high-quality fertilizer, electricity, heat, complete waste recycling, greenhouse gas reduction and environmental protection from pollutants [5]. Biogas has relatively lower methane content of 50–60% than LPG and CNG, even as inexpensive, renewable and inflammable strategies insist on commercialization of biogas to replace LPG and CNG all over the world. Technologies reside in the recent past to improve the quantity and quality of the biogas were not sufficient to capture absolute methane from various sources that desires further application of science and technology over the revealed concern [6]. Feasibility of anaerobic digestion systems is highly influenced by feedstock characteristics, operating conditions and digester design as revealed previously. Microorganisms are ubiquitous, so as to involve in the degradation of various organic materials as evidenced by the degradation of organic matter occurs naturally in nature. Indeed, microbial dynamics and feedstock depiction often generous to obtain an exacting remedy for the present energy thriving scenario. The four stages of anaerobic digestion require respective microbial enzymes along with various operational parameters. In this context, the present review critically evaluates the existing strategies undertaken by various aspects of anaerobic digestion for enhancing biogas production for the time being.

2. Sustainable utilization of feedstock for biogas production

During the past century, demand of energy increased significantly while its economic production does not attain the threshold due to few concerns. Conversely deplorable human activities consequences the damping of huge quantity of organic wastes that accelerating towards the release of greenhouse gases to the environment, resulting the alternation of economic balance of the ecological system. Efforts should focus on diminishing the detrimental effects abutting organic wastes through the utilization of the same as feedstock for biogas production. The exploration of organic wastes for energy production has extended significantly nowadays due to its impressive strides in the sustainable development through energy production and waste management [7]. In ancient years, anaerobic digestion systems restricted to vegetable and animal waste treatment whilst the same is at present widely applied for the treatment of agricultural, industrial and municipal solid wastes to obtain biogas alongside to assure waste reduction and environmental protection [8]. However, one of the noted problems hindering the success of anaerobic digestion is the feedstock accomplished in the course could not suffice to meet desired energy production for today's energy demand.

Cellulose, hemicelluloses and lignin are the chief components of all sorts of biomass that could serve as pertinent substrate for the growth of a degree of microbes those persuade anaerobic digestion. The stability and efficacy of digestion process has been prejudiced by the composition of various components in the feedstock. Physical and chemical characteristics of the feedstock such as moisture content, volatile solids, nutrient contents, particle size and biodegradability could exceedingly affect the process stability and biogas production [9]. Assessment of biogas production from various organic wastes showed that the exploitation of animal manure is higher when compared to agro-industrial wastes and municipal solid waste, as depicted in the Fig. 1 [6]. Among agricultural and fruit wastes used, fruit wastes are more appropriate for biogas production. Sagagi in 2009 reported that fruit wastes such as pineapple and orange wastes furnish better methane yield than wastes of vegetables such as spinach and pumpkin [10]. Since exploring the nature of various organic wastes has become essential at the current scenario to ensure the feasibility of additional feedstock for biogas production. Though, the effective utilization of feedstock can be accomplished by processing it with advanced knowledge. Technological modifications point towards a probable increase in biogas production can be achieved through various prospects such as the relevant feedstock selection, co-digestion experiments and pretreatment process, has been described genuinely below.

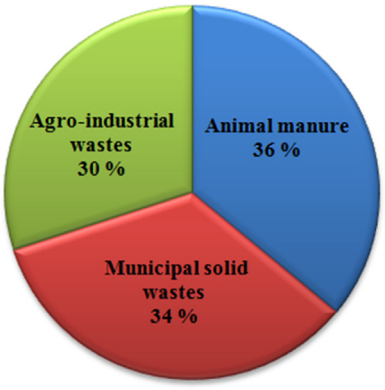

Fig. 1. Overall assessment of biogas production from prominent wastes.