International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(1): 35-38

Received: 09-11-2016
Accepted: 10-12-2016

Production of biohydrogen gas from sewage wastewater by anaerobic fermentation process

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Abstract
Hydrogen is view as a very clean energy source, since its combustion release mainly H_2O as a reaction product additionally it has advantage of having the highest energy density when compared to any other fuel. This research article summaries the fermentative production of biohydrogen gas and removal of pollution load from Sewage wastewater. In this study various parameters like contact time, pH value, reactor operating temperature are considered. An anaerobic batch reactor along with at magnetic stirrer having working volume of 1.5 litres was constructed and operated for 12 days. The temperature of the CSTR was regulated at atmospheric temperature. Biohydrogen gas obtained after 12 days about 106 ml at pH value 6.0-5.7, atmospheric temperature 26±2 ºC. Colour of the substrate was Dark medium gray when maximum of obtained.

Keywords: Sewage wastewater, biohydrogen, fermentation, yeast, dark-fermentation

1. Introduction

Nowadays, global energy requirements are mostly dependent on fossil fuels, which eventually lead to foreseeable depletion due to limited fossil energy resources. In recent times a great deal of attention is being paid to the usage of hydrogen as alternative and eco-friendly fuel throughout the world (Mohan *et al*., 2007) [4]. Recent reviews on hydrogen indicated that the worldwide need on hydrogen is increasing with a growth rate of nearly 12% per year for the time being and contribution of hydrogen to total energy market will be 8-10% by 2025 (Pandu and Joseph, 2012) [5]. Biological production of H_2 is one of the alternative methods where processes can be operated at ambient temperatures and pressures, and are less energy intensive and more environmental friendly (Mohan *et al*., 2007) [4]. One of the great challenges in the coming decade is how to get new renewable energy sources that are environmental friendly and to replace high dependency on fossil fuels. Until recently, almost all of the energy needed is mostly derived from the conversion of fossil energy sources, such as for power generation, industrial and transportation equipment that uses fossil fuels as a source of energy. Fossil fuels are source of non-renewable energy and also have seriously negative impacts on the environment (Wahab *et al*., 2014) [7]. Hydrogen gas is a clean energy source with a high energy content of 122 KJg^{-1}. Unlike fossil, fuels hydrogen does not cause any CO_2, CO, SOx and NOx emissions producing water as its only by-product when it burns reducing greenhouse effects considerably. Hydrogen is considered to be a major energy carrier of the future and can directly be used in fuel cells for electricity generation. Biological method mainly includes photosynthetic hydrogen production (photo fermentation) and fermentative hydrogen production (dark fermentation) (González *et al*., 2011) [2].

Sewage sludge is an important renewable energy source, which unlike others can be more harmful to the environment if not utilized or properly disposed. Using sewage sludge as the substrate for fermentative hydrogen production offers several advantages over the use of other biomass sources. It is available at little or no cost. The supply is plentiful and can be found wherever there are human settlements. The prime advantage is expensive management and disposal of sewage sludge can be surmounted. The sewage sludge of wastewater treatment plants is composed largely of organic matters (59-88%) that can decompose and produce offensive odours. These organics are mainly the microbial matters and the microorganisms include hydrogen producing ones and hydrogen consuming ones.

The treatment and disposal of the excess sludge has become an important problem and a great challenge for many plants. Anaerobic digestion is an appropriate technique for reduction in the volume and weight of excess sludge before final disposal, and it is employed worldwide as the oldest and most important process for sludge stabilization. Additionally, anaerobic digestion can recover partly the Bioenergy of sludge through producing methane (Senturk and Buyukgungor, 2013) [6]. Anaerobic sewage sludge contains a variety of mixed microflora for efficient hydrogen production from organic wastes in completely stirred tank reactor (CSTR) fermenters. An up-flow anaerobic sludge blanket (UASB) process is an extensively applied anaerobic treatment system with high efficiency and a short hydraulic retention time (HRT). This process can maintain high concentrations of large biogranules with high bioactivity for efficient reactor operation (Chang and Lin, 2007) [1].

Dark fermentation, traditionally known as anaerobic digestion, is considered as a feasible process because it generates bio-hydrogen from carbohydrate substrates including biomass and organic waste materials. However, the yield of bio-H_2 is relatively low, since H_2 is produced as an intermediate and can be further reduced to methane, acetate and propionate by hydrogen-consuming bacteria (HCB) during dark fermentation. To increase the production rate of biohydrogen, more attention needs to be given to developing methods that inhibit the activity of HCB and exclusively enrich hydrogen-producing bacteria. Critical factors in biological H_2 production are pH, temperature, feed concentration, bacterial population, retention period, etc. (González *et al*., 2011) [2]. The major criteria for the selection of waste materials to be used in biohydrogen production are the availability, cost, carbohydrate content, organic loading and biodegradability. Simple sugars such as glucose, sucrose and lactose are readily biodegradable and preferred substrates for hydrogen production. However, pure carbohydrate sources are expensive raw materials for hydrogen production. Major waste materials which can be used for hydrogen gas production may be summarized as follows. Some biodegradable carbohydrate containing and non-toxic industrial effluents such as dairy industry, olive mill, baker's yeast and brewery wastewaters can be used as raw material for bio-hydrogen production. Carbohydrate rich food industry effluents may be further processed to convert the carbohydrate content to organic acids and then to hydrogen gas by using proper bio-processing technologies (Kargi *et al*., 2006) [3].

Therefore, the main objectives of this study were to look for the impacts of fermentative hydrogen production from sewage wastewater in terms of time duration, atmospheric temperature and condition to investigate the impacts of an initial pH (6.0) on organic wastes for enhancing the biohydrogen production.

2. Material and methods

For conducting the experimental work Sewage wastewater collected from the local area Ujjain Madhya Pradesh, India. The wastewater can be considered as complex in nature due to the presence of organic matter and it contains various bacteria

2.1 Reagent

All chemicals used in present work were either of analytical reagent (AR) or laboratory reagent (LR) grade. Orthophosphoric acid (88-93% w/w), Sulphuric acid (H_2SO_4, 98% w/w), Sodium Hydroxide and Hydrochloric acid HCl (98% w/w, 36N) solution was used to maintained pH in the reactor.

2.2 Sample Preparation Method

After collection, the Sewage wastewater was transferred immediately to the laboratory and stored at 4 ^{0}C. A known volume 1000 ml of Sewage Wastewater was mixed with 10 gm. Yeast culture and fungus added to the requisite organic loading rate (OLR) prior to feeding into the reactor and pH adjustment. The experiment work conducted at the laboratory of the Chemical Engineering Department, Ujjain Engineering College, Ujjain (M.P.) India and sample test were carried out in the laboratory of Pollution Control Board, Ujjain (M.P.). Test for the pollution load were conduct as per the standard method of testing APHA (Standard method for examination of water and wastewater, 20th edition, 1998).

2.3. Batch reactor experimental setup

Lab-scale apparatus was installed in the laboratory of Chemical Engineering Department, UEC Ujjain (M.P.) India. The reactor has a magnetic pellet at the centre of a 2 axial blade turbine, which rotates about its axis with the help of magnetic force developed by a magnetic stirrer. Batch anaerobic studies were conducted in borosil glass reactor with a liquid total volume of 2000 ml and working volume of 1500 ml.

2.4 Batch mode anaerobic studies

The production of biohydrogen gas and removal of pollution load were studied by batch technique. These indicate that the Sewage wastewater participated as primary carbon source in metabolic reactions involving molecular H_2 generation. The substrate in borosil glass reactor placed on magnetic stirrer for known period of time. The substrate was checked daily for pH, temperature, colour and volume of gas obtain. The balloon test was applied for the analysis of biohydrogen gas. The pH value was obtained using pH meter.

3. Results and Discussion

This Section presents the results obtained from the batch studies of biohydrogen gas production and removal of pollution load by the Sewage wastewater as substrates. Wastewater is one of the significant environmental problems due to their toxic nature, so it is necessary to have treatment of wastewater and simultaneously producing valuable biohydrogen gas. The parameters studied include pH, atmospheric temperature and colour of the substrate.

3.1 Effect of time and pH on production of biohydrogen gas by using sewage wastewater as substrate

Effect of various parameters like time, Avg. Temperature, pH and colour changes during reactor operation for production of biohydrogen gas from sewage wastewater as substrate (Table No. 1)

Table 1: Various parameters changes during reactor operation for production of bio hydrogen from sewage wastewater as substrate.

Time in Days	Avg. Temperature in ^{0}C	pH	Gas obtained in ml	Colour
1	23.0	6	Nil	Pastel gray
2	28.0	6	Nil	
3	28.0	6	Nil	
4	24.0	5.9	Nil	
5	23.0	5.9	20	Dark medium gray
6	22.0	5.9	20	
7	24.0	5.8	28	
8	24.0	5.8	15	
9	27.0	5.8	15	Ash gray
10	30.0	5.8	08	
11	31.2	5.7	Nil	
12	30.0	5.7	Nil	

3.2.1. Effect of time

Since a high rate of methanogenic activity, the hydrogen gas production was very low in the initial period of reactor operation. After 96 h (4 days) of initiation period the production of biohydrogen gas was found to be around 20 ml of the gas produced. Then the biohydrogen gas production was gradually increased and it reaches the maximum of 28 ml of the gas collected in the 7th day of reactor operation (Figure 1).

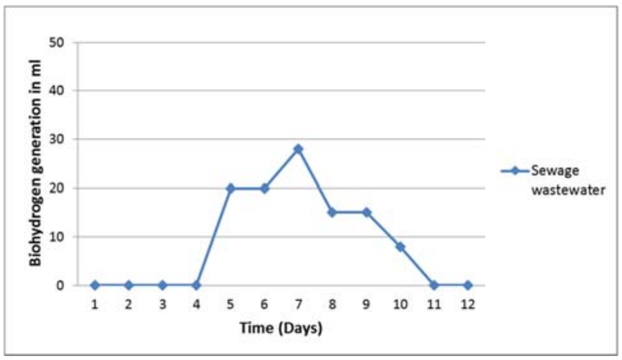

Fig 1: Effect of Time on production of bio hydrogen from sewage wastewater as substrate.

The result obtained from this study are effective for production of biohydrogen gas from sewage wastewater and the change in pH (decreases) with respect to time due to acid formation into the reactor show in figure 2.

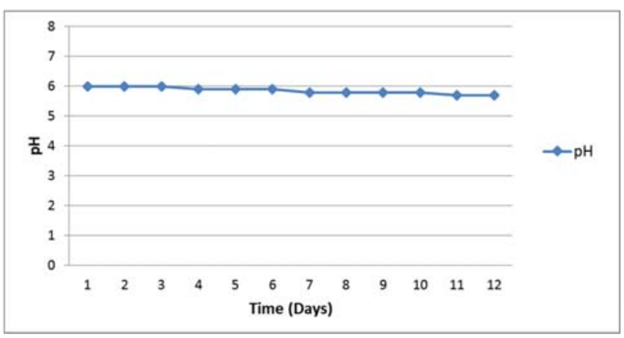

Fig 2: Change in pH with respect to time by Sewage wastewater as substrate.

3.1.2 Effect of pH: Bacteria respond to change in pH by adjusting their activity and synthesis of proteins. This is especially important for fermentative H_2 production where activity of acidogenic group of bacteria is considered to be crucial and rate limiting. From literature the pH range 5.5-6.0 is ideal to avoid methanogenesis.

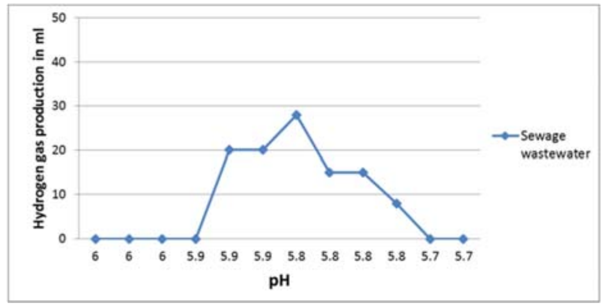

Fig. 3: production of biohydrogen gas with respect pH from sewage wastewater as substrate.

4. Conclusion

The study indicated that the feasibility of biohydrogen generation from sewage wastewater by anaerobic fermentation in a batch reactor. Production of biohydrogen gas and removal of pollution load is observed in sewage wastewater due to high organic matter. The selected reactor operating conditions (acidophilic pH 6) were found to be for effective for biohydrogen production. The experiment results showed that maximum biohydrogen gas production (68 ml) at 5-7 days and pH value is 5.9-5.8, substrate colour show dark medium gray and temperature was showed 26±2 ºC. The described process has a dual benefit of biohydrogen gas production with simultaneous reduction of pollution load of dairy wastewater in an economical, effective, and sustainable way.

5. Reference

1. Chang FY, Lin CY. Fermentative Hydrogen Production using Granulated Sewage Sludge Microflora. J. Environ. Eng. Manage. 2007; 17(1):57-62.
2. González LJR, Dávila IMMM, García YG, De la Garza JAR, Martínez JR. Biohydrogen production from diary processing wastewater by anaerobic biofilm reactors. African Journal of Biotechnology. 2011; 10(27):5320-5326.
3. Kargi F, Kapdan IK. Bio-hydrogen production from waste materials Enzyme and Microbial Technology. 2006; 38:569-582.
4. Mohan SV, Babu VL, Sarma PN. Anaerobic biohydrogen production from dairy wastewater treatment in sequencing batch reactor (AnSBR): Effect of organic loading rate. Enzyme and Microbial Technology, 2007; 41:506-515.
5. Pandu K, Joseph S. Comparisons and limitations of Bio-hydrogen production processes: a review. International

Journal of Advances in Engineering & Technology. 2012; 2:342-356.

6. Senturk I, Buyukgungor H. Energy from Sewage Sludge under Thermophilic Conditions. Springer journal. 2013, 1-20.
7. Wahab AKA, Azwar MY, Hussain MA. Development of biohydrogen production by photo biological, fermentation and electrochemical processes: A review. Elsevier Renewable and Sustainable Energy Reviews. 2014; 31:158-173.