

Research Article



Study of cell growth kinetics of biohydrogen production using distillery wastewater as substrate

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Abstract

Distillery wastewater was used as substrate for biohydrogen production. The initial substrate concentration of 11,000 mg COD/L was maintained for biohydrogen production and cell growth kinetics. Investigation of cell growth kinetics was studied using unstructured model in the present study. The kinetic parameters were  $K_c = 0.019 \text{ h}^{-1}$ ; simulated  $X_{\max} = 7965.71 \text{ mg/L}$ . The correlation co-efficient of 0.914, suggests that logistic model can be applied for cell growth kinetics of biohydrogen production.

**Keywords:** Cell growth kinetics, Logistic model and Biohydrogen production.

Introduction

Microbial growth kinetics is an indispensable tool in microbiology, physiology, genetics, ecology, or biotechnology. Microbial growth kinetics of cells is studied in the laboratory in batch, continuous, fed-batch systems. Substrate utilization or the increase in biomass concentration is monitored as a function of time. Environment, composition and physiological state of cell changes in batch system. The exact determination of the growth-controlling substrate concentration is difficult whereas determination of the specific growth rate is easy. It is difficult to determine the lowest growth-controlling substrate concentrations, hence kinetic experiments are carried out in batch cultures to determine the growth controlling substrate. (Kovar and Egli, 1998; Wang and Wan, 2008; Wang and Wan, 2009).

Logistic model

The specific cell growth rate is calculated using logistic model and is given by (Eq.1)

$$\mu = \frac{dx}{dt} = K_c \left( 1 - \frac{X}{X_{\max}} \right) \quad \text{Eq.1}$$

Where,  $K_c$  is the apparent specific growth rate ( $\text{h}^{-1}$ ), and  $X_{\max}$  is the maximum cell dry weight concentration ( $\text{g L}^{-1}$ ). By integrating Eq. (1), the following equation for cell concentration is obtained (Eq. 2):

$$X = \frac{X_0 \exp(K_c t)}{1 - (X_0 / X_{\max})(1 - \exp(K_c t))} \quad \text{Eq. 2}$$

Where,  $X_0$  ( $\text{g L}^{-1}$ ) is the initial microbial concentration ( $\text{g VSS L}^{-1}$ ), and  $X_{\max}$  ( $\text{g L}^{-1}$ ) is the maximum microbial concentration ( $\text{g VSS L}^{-1}$ ).

## Materials and Methods

### Substrate

#### Distillery wastewater

Distillery wastewater was collected from Distillery unit, Tamil Nadu, India. It was used as substrate. The initial substrate concentration for biohydrogen production and cell growth kinetics was maintained at 11,000 mg COD/L. Glucose was added as carbon source along with wastewater for growth of microorganisms. Due to high organic content of distillery wastewater, they lack nutrients. Some micronutrients and trace metals are added for the growth of microorganisms for granulation. The nutrient medium for biomass growth contained the following composition (g/L).  $\text{NH}_4\text{Cl}$  - 0.5,  $\text{K}_2\text{HPO}_4$  - 0.25,  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$  - 0.3,  $\text{NiSO}_4$  - 0.016,  $\text{CoCl}_2$  - 0.025,  $\text{ZnCl}_2$  - 0.0115,  $\text{CuCl}_2$  - 0.0105,  $\text{CaCl}_2$  - 0.005,  $\text{MnCl}_2$  - 0.015 and  $\text{FeCl}_3$  - 0.005 (Sridevi et al., 2014).

#### Anaerobic sludge and Pretreatment of anaerobic sludge

The anaerobic sludge collected from anaerobic digester of Distillery unit, Tamilnadu, India. The anaerobic sludge was heat pretreated at  $102^\circ\text{C}$  for 1 hour to inhibit the methanogens (Sridevi et al., 2014) and also to speed up the hydrolysis, rate limiting step in anaerobic digestion.

#### Analytical methods

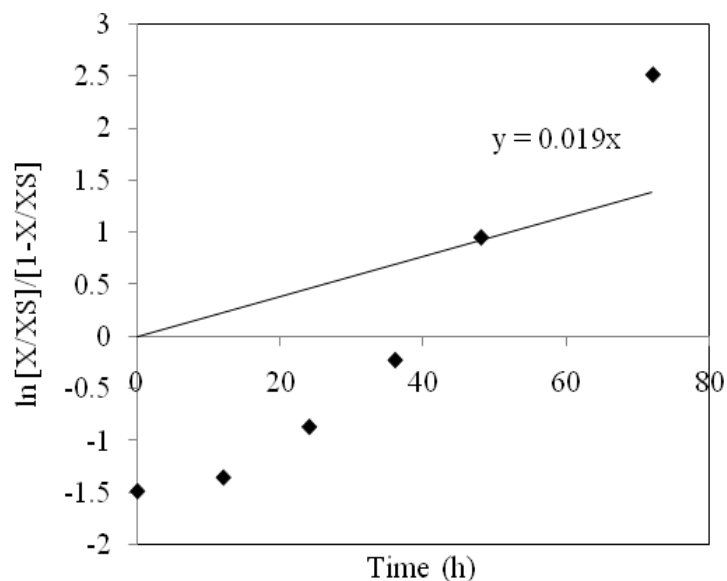
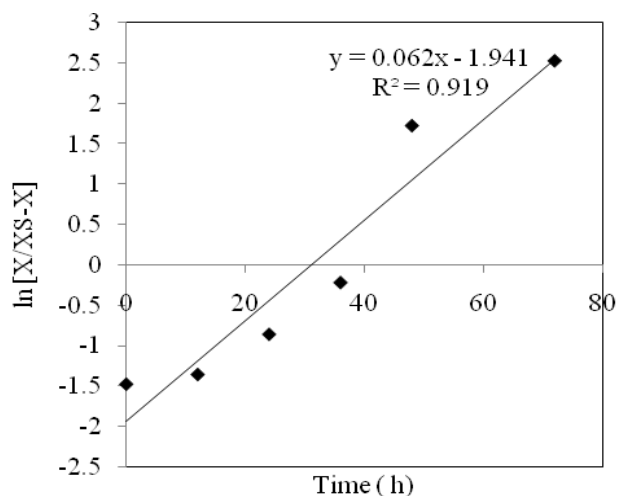
COD, pH, ORP and volatile suspended solids were determined according to standard methods of APHA (1995). COD, pH, ORP and volatile suspended solids (VSS) were recorded for every 24h while concentration was measured at steady state conditions.

## Results and Discussion

### Cell growth kinetics

The specific cell growth rate of hydrogen producing mixed consortia was calculated using logistic equation. From, Kinetic parameters were estimated as follows:  $K_c = 0.019 \text{ h}^{-1}$ , simulated  $X_{\text{max}} = 7695.71 \text{ mgVSS L}^{-1}$ . The experimental  $X_{\text{max}}$  was found to be  $5400 \text{ mgVSS L}^{-1}$ . The simulated VSS concentration was calculated using with the kinetic parameters. The high regression coefficient values,  $R^2 = 0.919$

indicated that the model fitted well. The higher value of simulated  $X_{\text{max}}$  than the experimental  $X_{\text{max}}$  is due to the difference between the viability of microorganisms. Similarly, Mu et al., 2006 also obtained a simulated  $X_{\text{max}}$  of  $9.46 \text{ g VSS/L}$ , while the experimental  $X_{\text{max}}$  was  $9.14 \text{ g VSS/L}$ . The  $K_c$  value was reported to be  $0.07 \text{ h}^{-1}$ . Gadhe et al., 2014 modelled the cell growth of hydrogen producing bacteria using Logistic equation and gave  $\mu_m$  and  $X_{\text{max}}$  as  $0.64 \text{ h}^{-1}$  and  $7.26 \text{ g VSS/L}$ .



Cell growth kinetics of biohydrogen production – Logistic model

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