

# Treatment of Dairy Wastewater by Anaerobic Digestion Process

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**Abstract**— In this study, experiments were conducted to investigate the production of biogas from dairy spent wash by using anaerobic digestion process. A laboratory scale digester with working volume of 8.0L was used. The experimental protocol was defined to examine the effect of the change in the organic loading rate on the efficiency of the production of biogas. The digester was operated at different organic feeding rates of 0.5, 1.0 and 1.5 kg COD/m<sup>3</sup>.d. The reactor showed stable performance with highest biogas yield of 1053ml with percent COD reduction of around 60.10% during loading rate of 1.5 kg COD/m<sup>3</sup>.d. As the time increased, percent COD removal and gas production increased and attained optimum value for each OLR. The maximum COD removal efficiency and gas produced on 30th, 61st and 91st day were 85.28%, 72.20%, 60.10% and 420mL, 825mL, 1053mL. Based on data from this study, implementation of anaerobic digestion as the method of waste treatment leads to the regional utilization of renewable energy resources, energy requirements and costs.

**Key words:** Anaerobic Digestion, BOD, COD, Organic Loading Rate (OLR), dairy spent washes, Reactors

## I. INTRODUCTION

There is a growing interest in alternate energy sources as a result of increased demand for energy coupled with a rise in the cost of available fuels. Rapid industrialization has resulted in the generation of a large quantity of effluents with high organic contents, which if treated suitably, can result in a perpetual source of energy. In spite of the fact that there is a negative environmental impact associated with industrialization, the effect can be minimized and energy can be tapped by means of anaerobic digestion of the wastewater. In recent years, considerable attention has been paid towards the development of reactors for anaerobic treatment of wastes leading to the conversion of organic molecules into biogas. The Anaerobic reactors, known as second generation reactors or high rate digesters, can handle wastes at a high organic loading rate of 24 kg COD/m<sup>3</sup> day and high up-flow velocity of 2±3 m/h at a low hydraulic retention time [1]. However, the treatment efficiencies of these reactors are sensitive to parameters like wastewater composition, especially the concentration of various ions [2] and presence of toxic compounds such as phenol [3]. The temperature and pH are also known to affect the performance of the reactor by affecting the degree of acidification of the effluent and the product formation [4]. An improvement in the efficiency of anaerobic digestion can be brought about by either suitably modifying the existing digester design or by incorporating appropriate advanced operating techniques. Thus, a anaerobic digester is found to be superior to the conventional processes and stable reactor performance [4]. The main objective of this study is to treat the Dairy spent wash using anaerobic process and to characterize the Dairy spent wash for various parameters such as pH, BOD, COD, alkalinity, etc. To study

the effect of organic loading on the performance of anaerobic digestion process and to find the amount of biogas produced.

### A. Anaerobic Digestion (Stages):

Biogas Production through anaerobic digestion is a biochemical process involving microbial flora of bacteria adapted to oxygen free environment to convert complex biological and organic wastes in sequential stages into Methane, the major energy fuel<sup>[5]</sup> (refer Figure no.1).

#### 1) Stage 1:

The *Hydrolytic Bacteria* primarily are involved in the breakdown of complex organic waste streams into simple sugars, fats and oils, and amino acids. This stage involves splitting of the complex organic biological molecules into simpler forms, the process is known as Hydrolysis or Liquefaction.

#### 2) Stage 2:

The *Fermentative Acidogenic Bacteria* convert the hydrolyzed portion into Organic acids.

#### 3) Stage 3:

The *Fermentative Acetogenic Bacteria* then convert the Organic acids into Hydrogen, Acetate and CO<sub>2</sub> (g).

#### 4) Stage 4:

Finally, the *Methane producing Bacteria*, the Methanogens simultaneously produce Biogas from the Acetate, or from Hydrogen and Carbon dioxide.

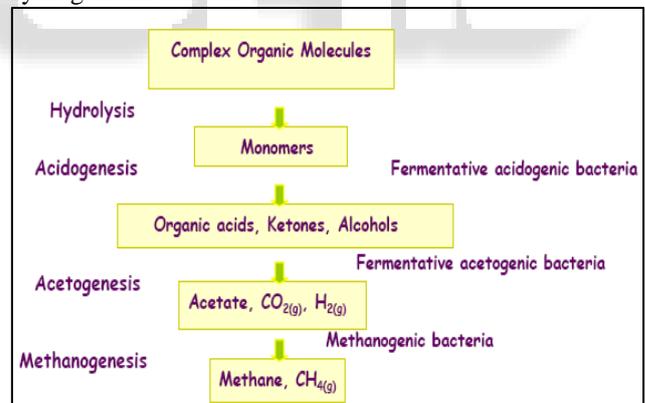


Fig. 1: Stages in anaerobic digestion

### B. Sources of Wastewater:

Process waste streams: Spent wash from the analyser column, Fermented sludge, Spent lees from the rectifier.

Non-process waste streams: Cooling water, Waste wash water, Water treatment plant wastewater, Boiler blow down, Bottling plant wash wastewater, other wastes.

## II. MATERIALS & METHODOLOGY

### A. Fabrication and Setting Up of Experimental Setup:

The schematic diagram of the experimental setup used for the present study is shown in Figure No.2. Aspirator bottle of 10 L (bottle no.1) capacity was used as digester

with working volume of 8L. The digester was connected to 5 L capacity bottle (bottle no.2), which contains the brine solution. The liquid displaced by generated gas is collected in the bottle no 3. The organic loading rate was calculated based upon the working volume of the digester. The organic loading on the digester were 0.5 Kg COD/m<sup>3</sup>.d, 1.0 Kg COD/m<sup>3</sup>.d, 1.5 Kg COD/m<sup>3</sup>.d

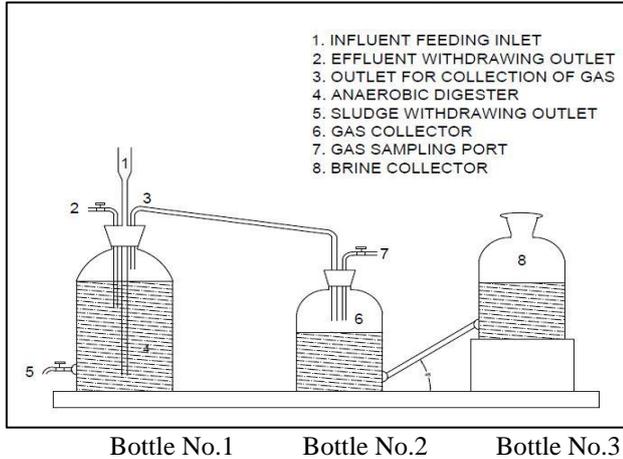


Fig. 2: Experimental Setup of anaerobic reactor

### B. Start Up of Reactor:

During the start-up of the reactor, the reactor was loaded with 7.0 L dairy spent wash & 1.0 L of cow-dung slurry with a COD concentration of 1832 mg/L, this mixture gave a composite COD of 5400mg/L. Daily the reactor was loaded with wastewater of volume 2.2L with a COD concentration of 1832 mg/L. After 4 days lapse of time the Gas collection started & by adjusting the reactor pH every-day the reactor was operated for 30 days for achieving stabilization. During various organic loading, 150ml of effluent sample was collected for analysis of various physico-chemical parameters such as pH, BOD, COD, alkalinity, total solids, etc. and the analysis were carried out as per the standard methods for the examination of water and wastewater (AWWA) 20<sup>th</sup> edition. The Organic Loading Rate and daily feed was calculated based upon the working volume of the digester (equation 1.0).

$$\text{OLR [kg/m}^3\text{.d]} = \frac{\text{Fresh Sewage added daily [kg/d]}}{\text{Volume [m}^3\text{]}} \quad (1)$$

### C. General Characteristics of Dairy Spent Wash:

The fresh wastewater samples were brought from "Nirzerneshwar milk processing plant, Maharashtra" to P.D.A Engg. College laboratory and preserved in deep freeze, to analyse the typical characteristics. The key pollutants in the spent wash from dairies are organic compounds and solids. Biodegradability may be estimated on the basis of BOD / COD ratio. This ratio ranges between 0.42-0.64, which indicates that the part of the organic compounds in the waste water is not easily biodegradable. The BOD<sub>5</sub> is 1240mg/L, COD is 1832mg/L & Total Solids in wastewater was found to be 2380mg/L. The pH value in this case varies from 7.8-9.2. When wastewater contains high concentration of organic matter, dissolved oxygen depletes because of the breakdown of organic matter, in absence of oxygen, sulphate acts as an electron acceptor to produce H<sub>2</sub>S and odour.

## III. RESULTS & DISCUSSION

The reactor was started with an OLR of 0.5 kg COD/m<sup>3</sup>.d and operated for a period of 30days till it attains stabilization. During this period the pH is maintained from 7.00-7.04. The alkalinity increased from 700-1098mg/L & COD reduced from 1590-795mg/L, refer Figure No.3. On 30<sup>th</sup> day the maximum COD removal efficiency obtained is 85.28 % & gas produced is 420mL. As the time increased, %COD removal increased & attained optimum value on 30<sup>th</sup> day.

When the OLR was increased from 0.5 to 1.0 kg COD/m<sup>3</sup>.d (35<sup>th</sup>-61<sup>st</sup> day) & operated for a period of 27days till it attains stabilization. Throughout the study period the pH is maintained from 7.04-7.10, the alkalinity increased from 600-980 mg/L & COD reduced from 2100-1501mg/L, refer Figure No.4. On 61<sup>st</sup> day the maximum COD removal efficiency obtained is 72.20 % & gas produced is 825mL. As the time increased, %COD removal increased & attained optimum value on 61<sup>st</sup> day.

When the OLR was increased from 1.0 to 1.5 kg COD/m<sup>3</sup>.d (66<sup>th</sup>-91<sup>st</sup> day) & operated for a period of 26days till the reactor stabilises. Throughout the study period the pH is maintained from 7.02-7.08, the alkalinity increased from 450-750 mg/L & COD reduced from 2585-2155 mg/L refer Figure No.5. On 91<sup>st</sup> day the maximum COD removal efficiency obtained is 60.10 % & gas produced is 1053mL. As the time increased, %COD removal increased & attained optimum value on 91<sup>st</sup> day.

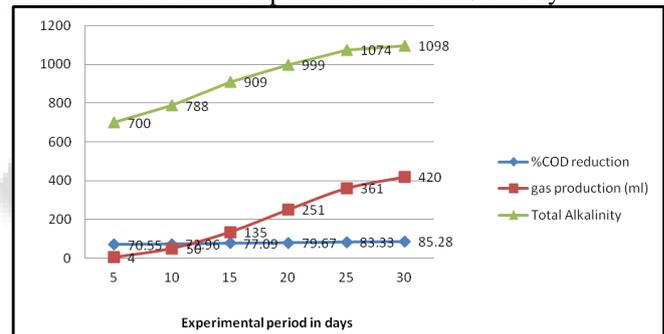


Fig. 3: Graph of Total Alkalinity, percent COD removal and Gas production for OLR=0.5 kg COD/m<sup>3</sup>.d

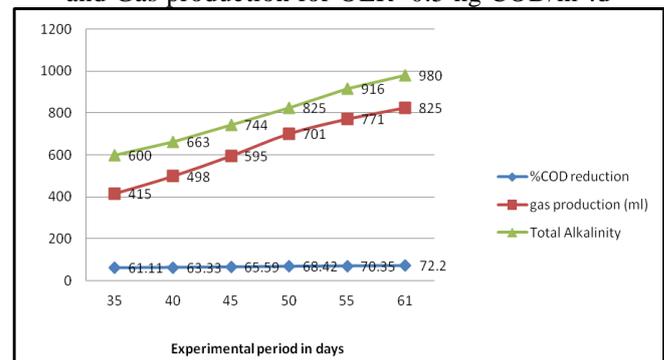


Fig. 4: Graph of Total Alkalinity, percent COD removal and Gas production for OLR=1.0 kg COD/m<sup>3</sup>.d

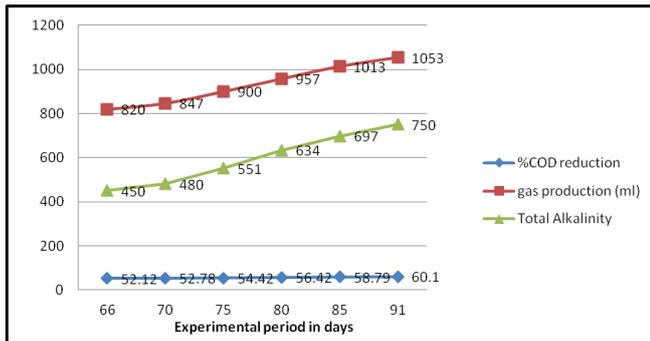


Fig. 5: Graph of Total Alkalinity, percent COD removal and Gas production for OLR=1.5 kg COD/m<sup>3</sup>.d

#### IV. CONCLUSIONS

Based on the experimental study it can be concluded that the spent wash is highly organic in nature having high value of COD (1832mg/L). The maximum COD removal efficiency is 85.28 % achieved after 30<sup>th</sup> day at an organic loading rate of 0.5 kg COD/ m<sup>3</sup>.d. The maximum biogas produced is 1053mL after 91<sup>st</sup> day of the start of reactor at an OLR of 1.5 kg/m<sup>3</sup>.d. It was noticed that the percent COD removal was increased and attained optimum value on 91<sup>st</sup> day from the start up. As the OLR was increased from 0.5 to 1.5 kg COD/m<sup>3</sup>.d, the volume of gas produced increased form 4-420mL, 415-825mL and 820-1053mL respectively, percent COD removal decreased from 70.55-85.28%, 61.11-72.20%, 52.12-60.10% and total alkalinity was decreased from 700-1098mg/L, 600-980mg/L and 450-750mg/L respectively.

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