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# Study of USAB Method of Treatment of Distillery Wastewater

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***ABSTRACT:*** *Anaerobic treatment is mostly preferred because of its low energy consumption and low nutrient requirement, besides this major possibility of energy recovery in the form of methane gas. Out of a variety of anaerobic reactor configurations currently available up-flow anaerobic sludge blanket (UASB) reactor is the effective one. In this anaerobic treatment complex organic matter gets converted into methane gas through the stages like hydrolysis, acidogenesis and methanogenesis[1]. The key to its success has been the spontaneous formation of small 'granular' bacterial pellets called granules in the reactor. These granules settle readily to the bottom of the reactor. Thus wastewater can be lifted relatively quickly through this reactor without turbulence to the bacterial granules. Therefore smaller reactors can be used, that cost less than standard anaerobic digesters and treat effectively large volumes of wastewater. A model to describe the processes occurring in a UASB reactor was developed and an experimental study of the anaerobic treatment of Distillery wastewater. In this experimental setup the COD removal rate is observed to be 60.43 % which is generally 65 %. The methane gas formation has been achieved 57 % and other gases 43 %. This paper reviews the suitability of treating distillery wastewater by UASB process and its potential for bio-energy generation.*

***Keywords:*** *Biogas Generation, Hydraulic retention time, Organic Loading Rate, Volatile Fatty Acid, Upflow Anaerobic Sludge Blanket (UASB)*

## I. Introduction

India is facing severe problems of collection, treatment and disposal of effluents due to rapid industrialization and urbanization. Anaerobic biological processes have received high attention in wasterwater treatment, owing to high capacity to treat slowly degradable substrates at high concentrations, very low sludge production, low energy requirements and possibility for energy recovery through methane combustion. One of the most notable developments in anerobic treatment process technology was the upflow anaerobic sludge blanket reactor (UASB) in late 1970's by Lettinga group in Netherlands[2]. UASB is widely accepted for treatment of a wide range of wastewater ranging from domestic sewage to industrial wastewater.

In Distillery industries high strength wastewater called spent wash is produced during the various processes, which is mainly organic in nature. Various physico-chemical and conventional biological processes have been applied for the treatment of it. If it is discharged without proper dilution or treatment, anaerobic conditions are developed in the receiving surface water bodies resulting in severe problems in river ecosystem on downstream side[3]. Hence it is necessary to reduce the pollution load of wastewater by selecting proper treatment method by keeping in view the primary aim to generate energy. Because of the high concentration of organic load, distillery spent wash is a potential source of renewable energy. One of the methods that are used for treating distillery wastewater is the application of UASB reactor. The UASB reactor has four major components sludge bed, sludge blanket, gas solid separator and settlement compartment[4]. The sludge bed is a layer of biomass settled at the bottom of reactor. The sludge blanket is the suspension of sludge particles mixed with gas produced in the process. Many factors have been found to affect the efficiency of UASB reactor such as temperature, wastewater composition, mixing, pH, OLR (Organic Loading Rate), and toxicity.

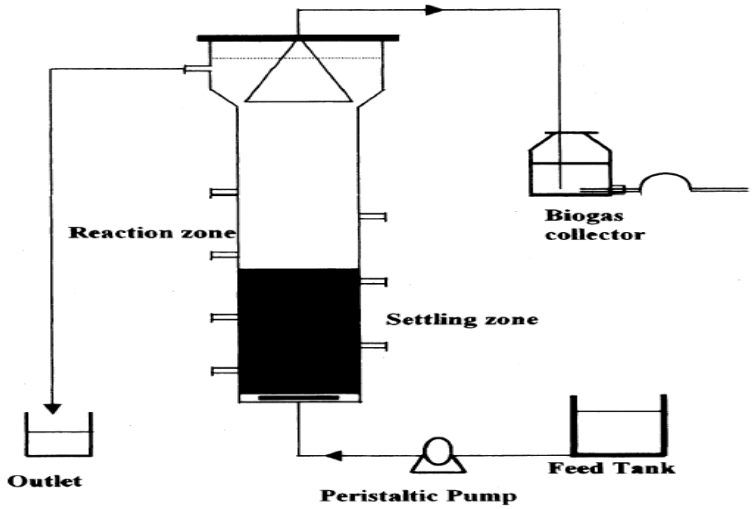


Fig.1. Schematic representation of the UASB reactor

## II. EXPERIMENTAL SETUP

UASB treatment was selected for treatment of Distillery wastewater generated in a sugar industry. The methodology comprises of collection of samples and its quantitative and qualitative analysis of untreated and treated wastewater at various levels in UASB after design and fabrication of lab scale circular reactor. After operation of UASB reactor for several months the performance is monitored and data is collected pertaining to COD reduction and methane formation.

## III. ANALYTICAL PROCEDURE

Spent wash, is high strength wastewater, varies with the production of alcohol. The volume of spent wash generated ranges from 14-15 liter for each liter of alcohol produced. It is highly acidic and normally micro-fauna can't survive in it, except fungi. When it is discharged in streams, it can affect Dissolved Oxygen (DO) Concentration and other temperature dependent reactions of physical, chemical and biological nature. Since the waste contains high BOD, it purifies rapidly giving rise to offensive odors. The dark brown color is aesthetical objectionable and affects photosynthesis. The typical characteristic of spent wash indicates that it is dark brown colored with highly acidic pH and high BOD, COD, TS and TVS etc.

## IV. Fabrication Of Laboratory Scale Reactor

A circular model of 10 liter capacity was fabricated using acrylic sheet. The diameter of reactor is 0.1142 m and height is 0.9759 m, so that it can accommodate 10 liter of design feed. Sampling ports were provided at the depth of 19 cm, 38 cm and 57 cm from the base plate and were named as Port No. 1, 2, and 3 respectively. Sludge washing port had been provided at 5 cm above the base of reactor[5]. Gas collector being an important part, it was carefully designed. The angle of inclination of faces of collector was kept $55^{\circ}$. Acrylic pipe of 1 cm internal diameter and 1.5 cm external diameter was attached to the gas collection cone at top and was further joined to gas collection pipe.

Table 1. Design Details of UASB Reactor

| | **Details** | **Unit** | **Scale of operation** |
|---|---|---|---|
| 1 | Capacity of reactor | $m^3$ | 0.01 |
| 2 | Reactor configuration | - | Circular |
| 3 | Building material | - | Acrylic |
| 4 | Height | m | 0.9759 |
| 5 | Bottom surface area | $m^2$ | 0.01 |
| 6 | Depth of digestion zone | m | 0.7807 |
| 7 | Depth of setting zone | m | 0.1952 |
| 8 | Types of wastewater | - | spent wash |

Table 2. Typical Conditions

| | Characteristic | Unit | Value |
|---|---|---|---|
| 1 | $P^H$ | - | 6.5-7.5 |
| 2 | Influent COD | mg/L | 85000-100000 |
| 3 | Influent Alkalinity | mg/L | 1,000-1,500 |
| 4 | Temperature | $^0$C | 35-38 |
| 5 | Max Gas Collection | % | 57 |

During fabrication, arrangement is made for three parts: aspiratory bottle filled with distilled water, displacement bottle and gas collection cone to collect gas. Gas formation takes place in the main frame of reactor. Gas then passes through rubber pipeline in to the aspiratory bottle which is having distilled water. This distilled water displaced from aspiratory bottle to displacement bottle because of the high pressure of gas coming out of reactor, then it is collected in gas cone.

## V. Pilot Run Of Lab-Scale Reactor

The reactor was inoculated with active sludge from an anaerobic reactor at the Sugar Factory. The wastewater feed was collected from the Distillery. The wastewater composition was with COD between 90000 to 100000 mg/lit and pH between 3.5 to 4.5. The reactor was operated at an HRT of 24hrs and temperature of 37$^o$C. This is the optimum temperature for mesophilic bacterial growth. During startup, the OLR was varied. The OLR was increased in a stepwise manner, until a sufficiently high loading rate was obtained. The criteria for efficient operation were VFA and COD reduction efficiency. The influent was fed to the lower part of the biomass composed of biologically formed granules, which were distributed uniformly in upward direction. The sludge blanket consumed the waste as it passes through it. The gases like methane and carbon dioxide are formed in this process. These gases cause internal circulation that helps in the formation and maintenance of biological granules. The gas and the suspended particles rise to the top of reactor. The particles with the attached gas rise to the surface, strike the bottom of baffles, due to which attached gas bubble gets released and is captured in gas collection domes at the top of reactor. The separated granules drop back to the surface of sludge blanket. The produced gas was collected through the top of the column by water displacement method[6]. The gas analysis was done by using Gas Chromatography Instrument. Sample from the reactor influent, sampling port and effluent were collected periodically for analysis of COD, VFA[7], alkalinity, acidity, suspended solids, VSS and pH, temperature, methane gas according to standard methods (APHA).

## VI. Result & Discussion

The data shows that COD reduction values in the 4$^{th}$ week is 26.53 % and it increases up to 60.43% at the 16$^{th}$ week and it is a good sign because standard values of COD reduction in percent is 60% to 65%.

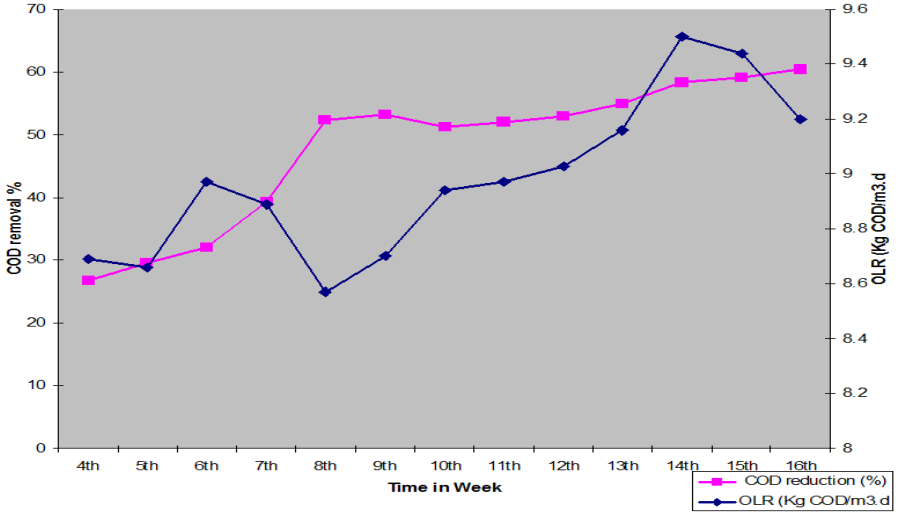


Fig.1. COD removal efficiency & OLR

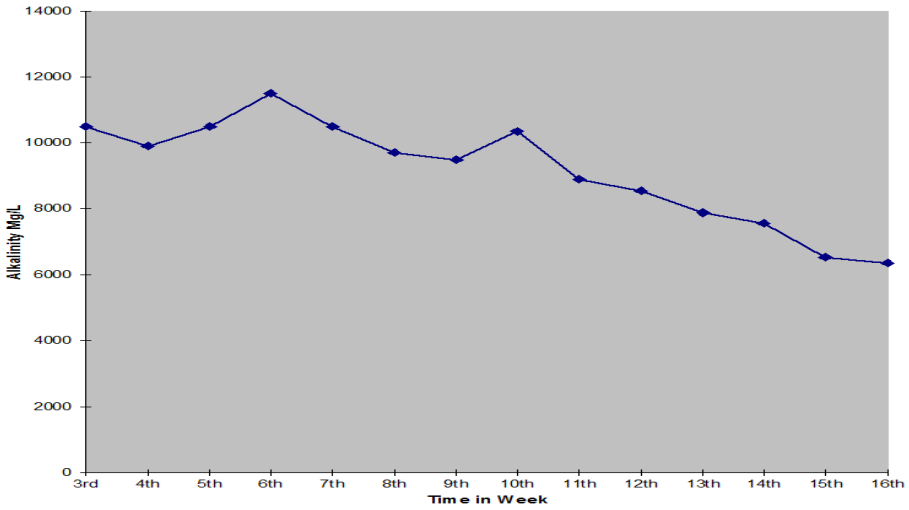


Fig.2. Alkalinity Vs Time

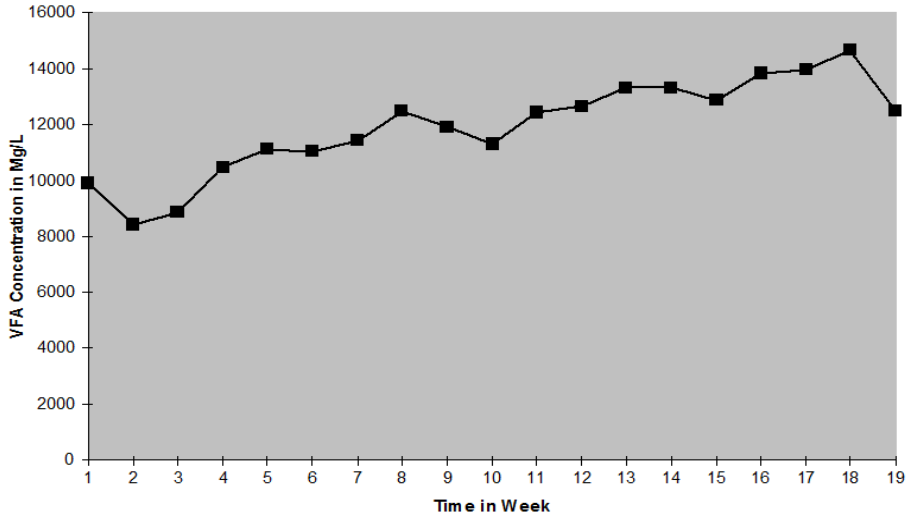


Fig.3. VFA Concentration in Composition Sample

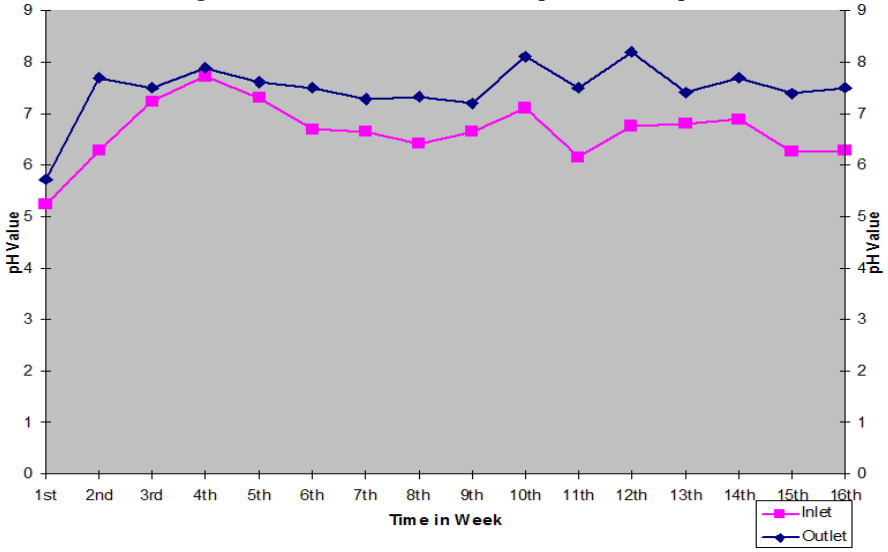


Fig.4. Average Weekly pH Value Against Time

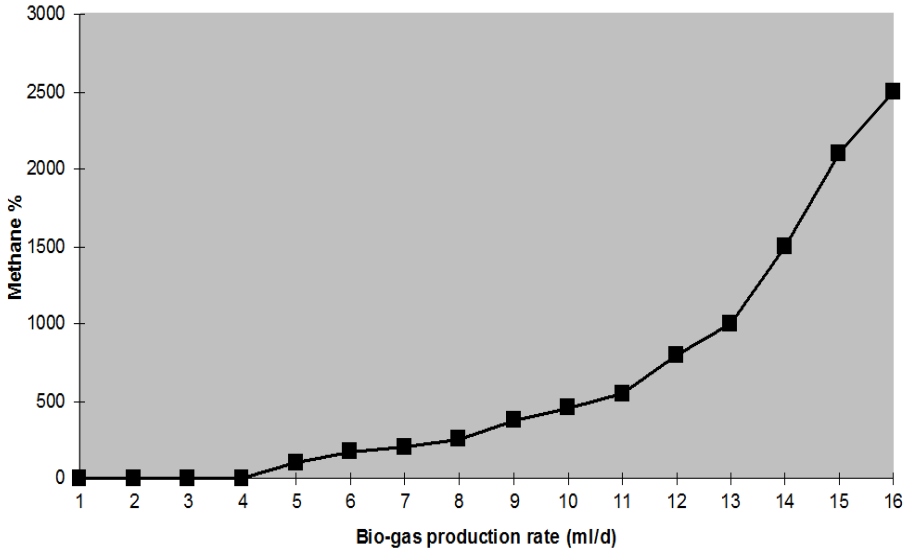


Fig.5. Bio-gas Production Rate

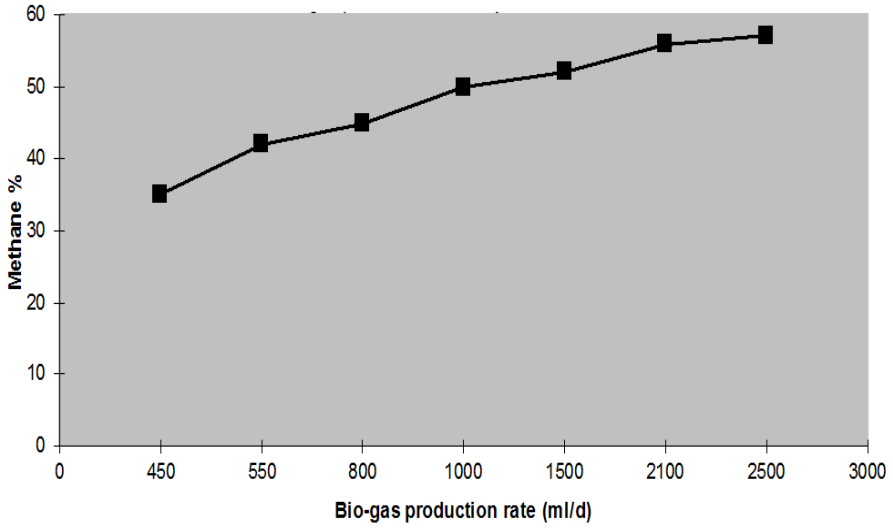


Fig.6. Methane Percentage

It is clearly indicated that the alkalinity value increases from 10500 mg/L to 11819 mg/L. Physical characteristics of wastewater such as pH and temperature etc. influence alkalinity values. If pH and temperature were maintained, then the alkalinity value comes between standard values 10000 to 15000 mg/L. Biogas yield under different OLR adopted during reactor operation is shown in the figures above. The biogas yield depends on reactor performance such as mixing condition inside the reactor, strength of granules developed and percentage of methane in biogas.

## VII. Conclusion

UASB technology has been found to be very effective for treatment of high strength industrial effluents particularly from distilleries. For high organic loads, it certainly offers advantages in terms of almost insignificant energy consumption, low operation and maintenance cost and recovery of significant amount of bio-energy. Consistent production of fairly large quantities of biogas from industrial effluents makes electricity generation for captive consumption an attractive financial proposition. Other features of the technology i.e. lower skill requirement and sludge production, perhaps add to its attractiveness under the industrial context to a certain extent. For instance, in distillery industry suitability of the technology has been amply demonstrated where due to bio-energy potential, the payback period has been found to be less than three years.

The biomass growth takes place on the fine sludge particles, which then develop on sludge grain of high specific gravity, which gives by-products such as energy resource in sugar factory. It is observed that biogas yield higher than $0.7m^3/m^3_{reactor}$/day is sufficient to carry out natural mixing inside the reactor. Therefore this process has enormous potential in removing pollutant from spent wash and production of biogas from effluent. It is evident that the COD removal rate in UASB reactor is 60.43 %. The methane gas formation has been achieved 57 % and other gases 43 %. Proper maintenance of certain parameters is very important in UASB process like pH, acidity, alkalinity, temperature etc. The performance of reactor is also governed by the quantity of active sludge retained in the reactor. The performance UASB reactor for the treatment of distillery waste water has been found to be satisfactory. The biogas potential of UASB is perceived to be promising and therefore it is recommended that UASB process is a good option for treatment of distillery waste water.

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