EVALUATION OF ANAEROBIC WASTEWATER TREATMENT AND SIMULTANEOUS BIOGAS GENERATION POTENTIAL FROM THE MILK PROCESSING FACTORY WASTEWATER IN THE MILITARY DAIRY FIRM, SAVAR

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ABSTRACT

Anaerobic treatment of high strength industrial wastewater is a well established industry in the developed world. Along with the treatment of wastewater requiring no aeration and thus being highly energy efficient the byproducts of anaerobic treatment hydrogen and methane gases are sources of clean renewable energy. This paper evaluates the potential of biogas generation in the Bangladesh Military Savar dairy milk processing facility by detailed characterization of the wastewater discharge flow pattern and characterization of the wastewater. A theoretical methane generation evaluation was conducted based on the wastewater flow and waste characterization. This was then related to the potential high value generation of electricity to show the potential of anaerobic agro based industry wastewater treatment with simultaneous generation of renewable energy.

Key Words: Anaerobic treatment, Hydrogen and Methane generation, Reactor Configuration.

1.0 INTRODUCTION

Anaerobic treatment of waste has been with us for quite a while. It has been used extensively for stabilization of waste with high solids content such as seen in anaerobic digesters. In Bangladesh we are very familiar on the application of anaerobic digester to stabilization of cow dung to produce biogas known as gobor-gas. Grameen Shakti has been extremely successful in introducing biogas production to rural Bangladesh using micro-financing. Unfortunately the application is limited to cowdung stabilization or chicken excrementstabilization in poultry farms. In pilot scale some municipalitiesin Bangladesh are attempting to introduce anaerobic stabilization of municipal solid waste to generate biogas. Although the application of anaerobic waste stabilization to low solids wastewater is well established in more developed economies in Bangladesh there has not been any application to date. Sadly we are missing out on a source of renewable energy, and low cost energy efficient effective method of wastewater treatment. In this paper we will introduce the effectiveness of anaerobic wastewater treatment by looking at awastewaters from the Bangladesh Military Savar dairy farm milk processing factory. We conducted a theoretical analysis as to the potential of anaerobic wastewater treatment as renewable energy generation potential both with respect to methane and hydrogen and potential for power generation. Figure 1 shows the steps involved in the stabilization of waste as substrate by the methanogenic process. The whole process occurs in the absence of oxygen and the enzyme mediated electron transfers occur between organic compounds and oxygen is not needed as a terminal electron acceptor [1, 2, and 3]. This means that the anaerobic wastewater treatment process will not only degrade the organics and make the wastewater safe for release as per regulations but also produce biogas which can then be used for electricity generation as a source of renewable energy.

A low solids wastewater from the Bangladesh Army milk processing factory in Savar served as our research test waste water. At present this waste water from the milk processing factory is discharged without any form of treatment. Thus by introducing anaerobic treatment of the milk processing factory wastewater one would stop the pollution and at the same time generate renewable energy.

2.0 METHODOLOGY

Time proportioned samples were obtained from each of the industries of concern in this paper and characterized in the laboratory as per Standard Methods with regards to the analytical procedure [4]. The parameters which were analyzed for the characterization of the composite samples were chemical oxygen demand, total solids, total suspended solids, ammonia nitrites, and nitrates, and phosphates. Statistical analysis was done by means of Excel spread sheet and all data reported as mean and standard deviation. To plot graphics Excel spreadsheet was used.

3.0 RESULTS

The Savar Bangladesh Army milk processing wastewater includes wash down water from all there reactor vessels along with the production floor wash water. The diurnal flow pattern of the wastewater discharged from the milk processing factory is shown in Figure 2. The flow pattern indicated that the wastewater is generated at a steady rate except for a period of two hours when the flow drops substantially. The hourly mean wastewater flow rate is 6735 L/hr calculated from the diurnal flow regime shown in Figure 2.

A detailed characterization of the wastewater was done by collecting timed proportioned composite sample by collecting equal volume of sample every hour for twenty four hour of wastewater flow. The twenty four hour wastewater composite sample was characterized for COD,TSS, Ammonia, Nitrite, Nitrate, and Phosphate. For each parameter the wastewater composite sample was analyzed three times. The result of the characterization study is summarized in Table1.

The methane generation potential based on COD converted is given by the Equation 1 and Equation 2 below [1,2,3]:

$CH_4\,(m^3/hr) = 0.4\cdot (S_o-S_e)\cdot Q$....................(1)

and

$S_e= (1-E\cdot S_o/100)$ ....(2)

where:

S_o = *influent COD in mg/L,*

S_e = *reactor effluent COD in mg/L,*

Q = *wastewater discharge rate m^3/hr, and*

E = *COD removal efficiency.*

The theoretical methane production based on equation (1) and equation (2) with the Q value of 6735 L/hr at an S_o value of 340 mg/L (from Table 1) and an e value of 93% based on anaerobic wastewater treatment efficiency for COD removal reported in literature [5] was:

Calculated CH_4 = 0.85 m^3/hr.

The electricity generation from methane can be calculated by using Equation (3) below:

$kWh = (n/100)\cdot 10.6\cdot V\cdot t$...........................(3)

Where:

n = energy to electricity conversion efficiency in %,

V= volume of methane in m^3/hr,and

t = hours of methane generation in hr.

For an average methane generation of 0.85 m^3/hr this would at an "n" value of 33 based on existing biogas generator performance efficiency the kWh of electrical energy would be 9.0. In terms of power this would be equal to 9000 watts [6]. This implies the untreated wastewater that is being discharged would have the capacity if harnessed by anaerobic treatment would be able to light 90/100 watt light bulbs per hour.

The diurnal pH trend shown in Figure 3 dose show that the pH is within the range of 6-8 the ideal range of operation of anaerobic reactors except for a spike of two hours of flow. An equalization basing with a 24hr retention would easily negate any short duration pH spike. Table 1 also shows that there is sufficient phosphate and nitrogen present not to require additional augmentation for microbial metabolic needs.

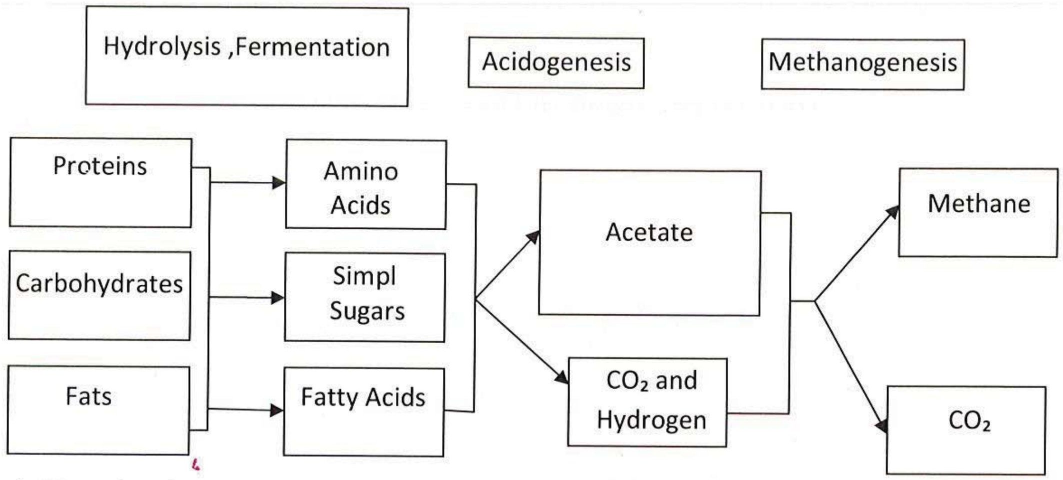

Fig. 1: Steps Involved in the Stabilization of Waste as Substrate by the Methanogenic process.

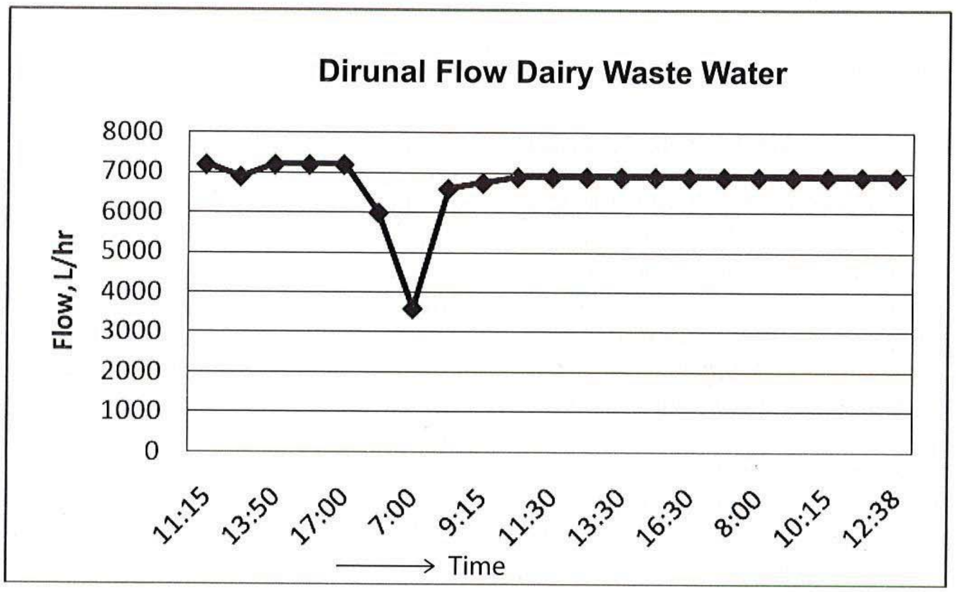

Fig. 2: Diurnal flow characterization of the wastewater generated in the Savar Milk Processing Factory.

Table1. Milk Processing Wastewater Characterization.

Parameter	Unit	Sample 1	Sample 2	Sample 3	Average	STD
TSS	mg/L	42	40	39	40.3	1.53
Ammonia	mg/L	0.16	0.15	0.15	0.2	0.01
Nitrite	mg/L	0.073	0.074	0.078	0.1	0.00
Nitrate	mg/L	0.7	0.8	0.8	0.8	0.06
Phosphate	mg/L	13.1	12.5	12.3	12.6	0.42
COD	mg/L	399	343	278	340.0	60.56

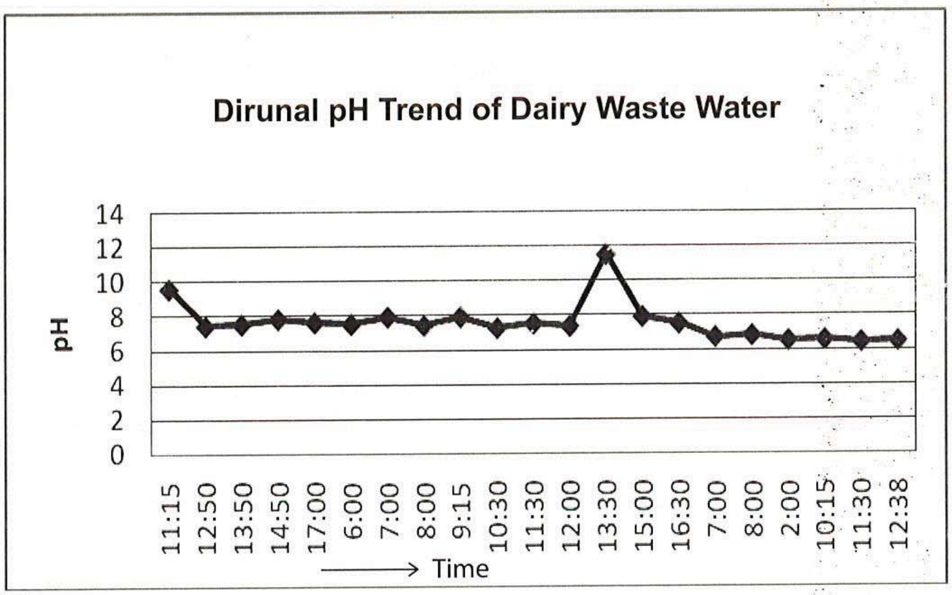

Fig. 3: Diurnal pH characterization of the wastewater generated in the Savar Milk Processing Factory.

4.0 DISCUSSION AND CONCLUSION

Application of anaerobic treatment for low strength wastewater is in the vanguard of technology application with the benefit that it is a cheaper energy efficient alternative to aerobic wastewater treatment that requires aeration. Anaerobic processes not only require no aeration thus more economical they also produce as a byproduct of wastewater treatment methane and hydrogen gas which are renewable fuels; both points are of value to Bangladesh with its scarcity of energy, especially in rural environments. Also, the stabilized sludge produced during anaerobic waste treatment is a high value organic fertilizer rich in nitrogen that can be directly applied to agricultural lands without further processing.

The Savar Military dairy milk processing facility is currently discharging 6735 L/hr of untreated wastewater containing 340 mg/L of COD which is much greater than the Bangladesh Department of Environment Discharge Limit for COD of 150 mg/L. A sequential batch anaerobic reactor would be ideal to treat this low strength wastewater and simultaneously methane gas. Sequential batch reactorsin theory would have infinite solids retention time and would follow zero order kinetics independent of substrate concentration for substrate stabilization and the reactor waste stabilization efficiency would only be dependent on the residence time of the reactor. Theoretically it would be possible to generate 0.85 m^3/hr of methane which would ensure the production of 9000 watts of power with the ability to light up 90 one hundred watt bulbs un-interrupted for 24 hrs a day. Instead of consuming electricity this wastewater treatment facility would generate renewable energy.

This paper based on detailed sampling and characterization of the wastewater showed the potential for renewable energy generation and simultaneous wastewater treatment. As a future scope of work the theoretical methane generation/energy production evaluation based on waste characterization reported in this study needs to be verified by conducting bench scale and pilot scale treatability studies and then proceed on to obtain actual kinetic parameters for design and operation of anaerobic effluent treatment plant for the Savar Military Dairy Milk Processing Factory.

5.0 ACKNOWLEDGEMENT

The authors great fully acknowledge the cooperation and support rendered by Military Dairy Firm authority in collecting and processing the data required for this study.

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