IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 2, March 2022

Biogas as a Value Generation from Dairy Industrial Waste Water

Shareen Fathima M, Hiritha N, Mounika M, Sureja A, Prabhu N*

Department of Biotechnology

Vivekanandha College of Engineering for Women, Elayampalyam, Tiruchengode, Tamil Nādu, India

*Corresponding Author: prabhu.aut.26@gmail.com

Abstract: *Dairy industry wastewater has a high chemical oxygen demand, a high biological oxygen demand, nutrients, and organic and inorganic components. If these wastewaters are not properly treated before being released, they will significantly contaminate recipient water bodies. There are various physical, chemical, and biological techniques for treating dairy waste water. Dairy waste, on the other hand, responds well to biological treatment. When microorganisms come into touch with the strongly aerated effluent, they oxidise the organic stuff to carbon dioxide and water. Microorganisms convert organic materials to biogas and cell biomass in anaerobic processes. Anaerobic digestion is a complicated chemical and biological process that is influenced by a variety of variables. Biogas is a renewable energy source that can be used as a long-term replacement for fossil fuels. The major objectives of this paper is to examine Bio-gas Generation and variables impacting Bio-gas Generation from dairy industry wastewater, such as pH, temperature, alkalinity, and so on, in order to maximise biogas release by biological breakdown. Biogas is the cheapest renewable energy source created in an engineered fashion from dairy sector effluent, according to the results.*

Keywords: Industrial Waste Water, Types, Dairy Waste Water, Anaerobic Digestion, Biogas Production

I. Introduction

Industrialisation plays a significant part in the growth of a country, but it also contributes to major pollution issues across the world. With rising demand for milk and milk products, the number and scale of dairy farms has exploded in many nations across the world. The dairy sector is a key source of food processing, and it uses a lot of water. Pasteurized and sterilised milk, yoghurt, ayran, cheese, cream, better, ice cream, and milk powder are only a few of the goods available in the dairy sector. Both the manufacture of goods and the packing of those goods generate waste water.[1]

Biogas may be made through anaerobic digestion of nearly any sort of organic material, including agricultural waste, industrial waste, and residential waste. The dairy sector, like most other agricultural industries, produces huge amounts of refractory effluent with high biological oxygen demand (BOD) and chemical requirement of oxygen concentrations (COD), indicating a high organic matter content. The release of industrial milk effluent has a major environmental effect, since in addition to the high organic matter concentrations, the effluents contain high oil and graft levels and the presence of suspended particles and odours generated by casein degradation. [2]. The adsorption of anaerobic digestion procedures in wastewater treatment facilities in the dairy sector stands out in this situation as the biological approach more suited to treating and pre-processing produced waste effluents.[3]

India is a major producer of milk and dairy products, with annual milk output exceeding 85 million tonnes in 2002 and increasing at a pace of 2.8 percent per year. Dairy effluent has significant levels of organic materials, namely Lactose, fat, and protein. Because of the fortified nutrients in cheese whey, a favourable habitat for Lactobacillus species is produced, which is beneficial in converting organic materials into methane via anaerobic process. The anaerobic treatment procedure is an effective method for converting dairy effluent to biogas.[4]

II. Industrial Waste Water

We are now preoccupied with the liquid portion of industrial waste, which is usually referred to as industrial waste water. Waste water, which is produced as a by-product of process unit operations, contains components that can be detrimental to humans, animals, plants, aquatic life, and microbiological life/different life forms on the planet.[5]

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, March 2022
Impact Factor: 6.252

2.1. Sources of Industrial Waste Water

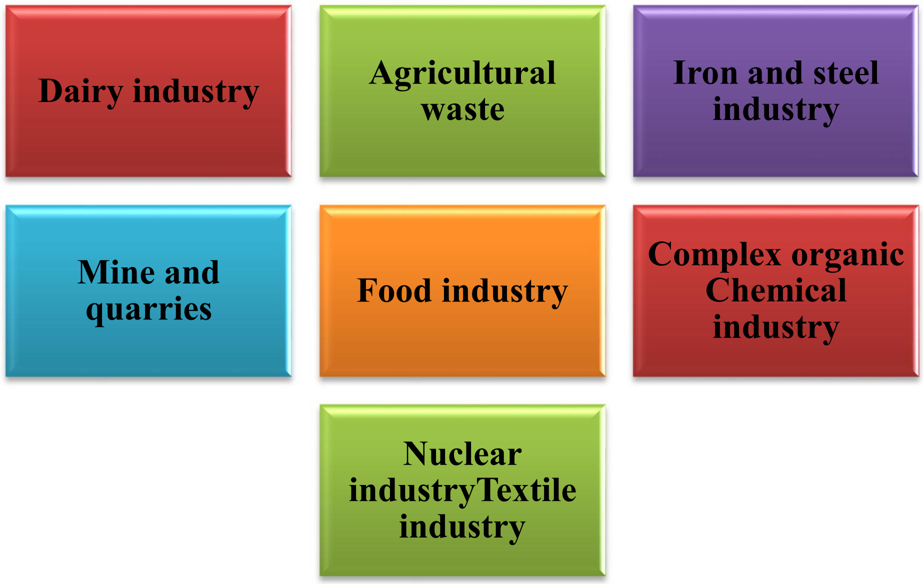

Figure 1. Sources of industrial wastewater

2.3. Characteristics of Industrial Waste Water

The properties of industrial waste water differ from one industry to the next, as well as from one process to the next, even within the same industry. They have either too high proportion of suspended solids, dissolved inorganic and organic solids, BOD alkalinity or acidity /and their different constituents will not be in the same proportion as the exist in a normal domestic sector.[6]

III. Waste Water Treatment Levels

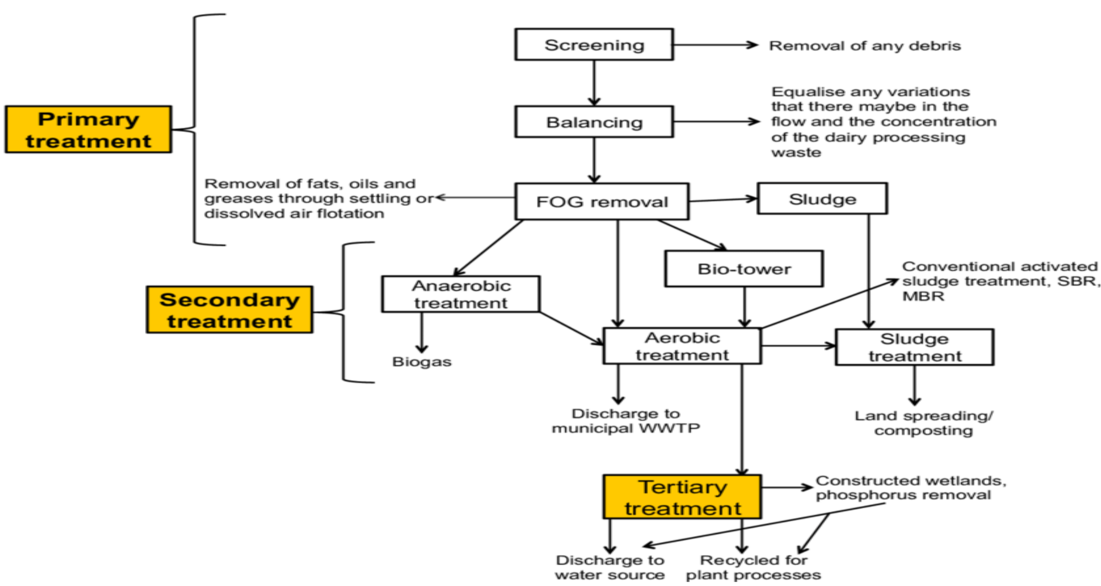

Figure 2. Waste water treatment levels

3.1. Preliminary Treatment

Waste water components such as rags, sticks, seaworthy grit, and lubricant are removed to avoid reliability issues with treatment systems, processes, and auxiliary systems.

3.2. Primary Treatment

A percentage of the colloidal matter and organic debris in the wastewater is removed. Improved wastewater elimination of suspended particles and organic materials. Primary treatment consists of following processes are sedimentation, coagulation and flocculation.

3.3. Secondary Treatment

Decomposable organic materials and colloidal solids are removed. In most cases, disinfection is included in the concept of typical secondary therapy. Secondary treatment consists of following processes are activated sludge process, oxidation ponds and lagoons and trickling filter.

3.4. Tertiary Treatment

After secondary treatment, remaining suspended particles are removed using solid matrix separation or micro screens. Disinfection is usually included in tertiary therapy. This section frequently includes nutrient removal. Tertiary treatment consists of following processes are chlorination /ozonation /UV, filtration, reverse osmosis, evaporation, post aeration

IV. Dairy Industrial Waste Water Treatment

Pasteurization or homogenization of milk, butter, cheese, or yoghurt creates waste water with significant BOD and COD loads, which can only be decreased and being sent to municipal treatment facilities. Buttermilk, whey, and derivatives are common by-products. During the process, a large volume of water is consumed, resulting in effluents comprising dissolved carbohydrates and proteins, lipids, and perhaps pharmaceutical remnants. (@2018 **Ecologix Environmental Systems,** LLC | 11800 Wills Rd Alpharetta GA 30009)

4.1. Operations in a Dairy Industry

Basic process of raw milk:

- Receiving
- Pasteurizing

Various manufactures:

- Bottling
- Condensing
- Dry milk manufacture
- Cheese manufacture
- Butter making
- Casein making

4.2. Dairy Wastes are made up of:[7]

1. Milk solids composed of BOD of 1 kg milk fat -0.89kg, BOD of 1 kg milk protein -1.03kg, and BOD of 1 kg of milk sugar -0.69kg
2. Dilutions of whole milk and by-products composed of Bod of whole milk-90,000 -1,05,000mg/l, BOD of skim milk-65,000-75,000mg/l, BOD of buttermilk-55,000-65,000mg/l and BOD of whey -25.000-35,000mg/l.
3. Waste water from: Equipment cleaning, Floor washing, Water softening, Boiler house and, Refrigeration plant.
4. Chemicals and detergents
5. Broken glass pieces, torn bags and aluminium foil.

4.3. Composition of the Waste Water of Typical Dairy Industries: [7]

Items	Influents
pH	7.2
Alkalinity	600 mg/l
Dissolved solids	1060 mg/l
Suspended solids	760 mg/l
BOD	1250 mg/l
COD	84 mg/l
Nitrogen	84 mg/l
Phosphorous	11.7 mg/l
Oil and grease	290 mg/l
Chloride	105 mg/l

4.4. The Sourced of the Dairy Industry Waste Water[8][9]

Dairy processes Preparation stages	Sources of waste
Milk recovering/ storage	• Poor damage of tankers • Spills and leaks from hoses and pipes • Spills from storage tanks • Foaming • Cleaning operations
Pasteurisation /ultra-heat treatment	• Liquid losses /leaks • Recovery of downgraded product • Cleaning operations • Foaming • Deposits on surfaces of pasteurisation and heating equipment
Homogenisation	• Liquid losses • Cleaning operation
Separation (Centrifuge, reverse osmosis)	• Foaming • Cleaning operation • Pipe leaks
Product processing stages	
Market milk	• Foaming • Product washing • Cleaning operation • Over filling • Poor damage • Sludge removal from clarifiers/separators

	• Leaks • Damaged milk packages • Cleaning of filling machinery
Cheese making	• Overfilling vats • Incomplete separation of whey from curd • Using salt in cheese making • Spills and leaks • Cleaning operations
Butter making	• Cleaning operations • Product washing
Powder manufacture	• Spills of powder handling • Start-up and shut down losses • Plant malfunction • Stack losses • Cleaning of evaporation and driers • Bagging losses

4.5. Effects of Dairy Effluents

The fast breakdown of dairy waste water lowers the dissolved oxygen level of receiving water and encourages the growth of sewage fungus by lowering the dissolved oxygen level of receiving water and lactose, which is a significant ingredient of waste.[10] When water is heavily polluted by dairy waste water, it provides a breeding ground for disease-carrying flies and mosquitos. The breakdown of casein precipitation produces a foul-smelling black sludge that is hazardous to aquatic life. They contribute to eutrophication, turbidity, and a strong unpleasant odour. The impact on the environment varies depending on the biodegradability and solubility of waste. Dairy waste water processing contains organic components that are highly decomposable.[11]

V. Biogas Production

5.1. Anaerobic Digestion:

Anaerobic digestion is a method of decomposing organic materials in the absence of oxygen. In the lack of oxygen, anaerobic bacteria consume organic molecules to generate methane and CO2. During the biogas generation in anaerobic digestion plants, a tiny quantity of hydrogen sulphide and ammonia, and therefore a trace of other gases, is generated.[12] Anaerobic digestion is a natural method that entails the transformation of organic material to different end products, such as methene and carbon dioxide, in a step-by-step manner[13].Pathogens will be killed during the production of bio gas, resulting in a cleaner atmosphere. During anaerobic digestion, and thus producing fertiliser enriched in NPK (nitrogen, phosphorus and potassium). Bio gas is used in cooking and illumination. Bio gas, like natural gas, may be compressed and utilised to power automobiles, among other things[14] .

5.2 Theory

Acetic acid-forming bacteria (acetogens) and methane-forming bacteria are among the microorganisms that impact anaerobic digestion (methanogens). These organisms stimulate a variety of chemical reactions as they convert biomass to biogas.[15]

Figure 3. Waste water treatment in dairy industries

The process includes four stages they areHydrolysis, Acidogenesis, Acetogenesis, and methanogenesis.[16]

A. Hydrolysis

Large polymer nanocomposites make up the majority of biomass. Fewer component pieces must be created by trying to break down into chains for the bacteria in anaerobic digesters to access the material's energy potential. Other bacteria may easily access these component elements, such as glucose. The act of unravelling these chains and dispersing the smaller molecules into solution is known as hydrolysis. As a result, the initial step in anaerobic digestion is to hydrolyse these high-molecular-weight polymeric components. Complex organic compounds hydrolyse to produce simple sugars, amino acids, and fatty acids.[17]

B. Acidogenesis

The components of the system are broken down by acidogenic bacteria, such as fermentative bacteria, in the biological process of acidogenesis.[18]VFAs, as well as ammonia, carbon dioxide, hydrogen sulphide, and other by-products, are produced here[19].

C. Acetogenesis

Acetogenesis is the third step of anaerobic digestion. Simple molecules produced during the acidogenesis phase are digested further by acetogens, which generate acetic acid, carbon dioxide, and hydrogen.[20]

D. Methanogenesis

Methanogenesis is the final stage of the anaerobic digestion process. Methanogens utilise the by-products from the previous stages to produce methane, carbon dioxide, and water. The bulk of the biogas released from the system was made up of these components. Methanogenesis occurs between pH 6.5 to pH 8, and is sensitive to both high and low pH.[21]

The following equations describe various products, by-products, and intermediate products that are generated during the digesting process of an anaerobic methane generation. The acids produced are processed by methanogenic bacteria to generate methane, which is described in the following equations. [22]

$CH_3COOH \rightarrow CH_4 + CO_2$

Acetic acid methane carbon dioxide

$2CH_3CH_2OH + CO_2 \rightarrow CH_4 + 2CH_3COOH$

Ethanol Carbon dioxide Methane Acetic acid

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

Carbon dioxide Hydrogen Methane Water

5.3. Methodology:[23]

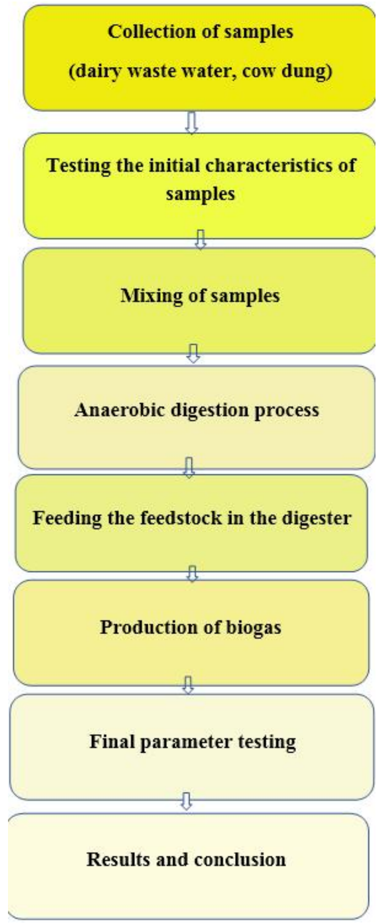

Figure 4. Waste water treatment steps in dairy industries

5.4. Biogas Production Procedure from Anaerobic Digester

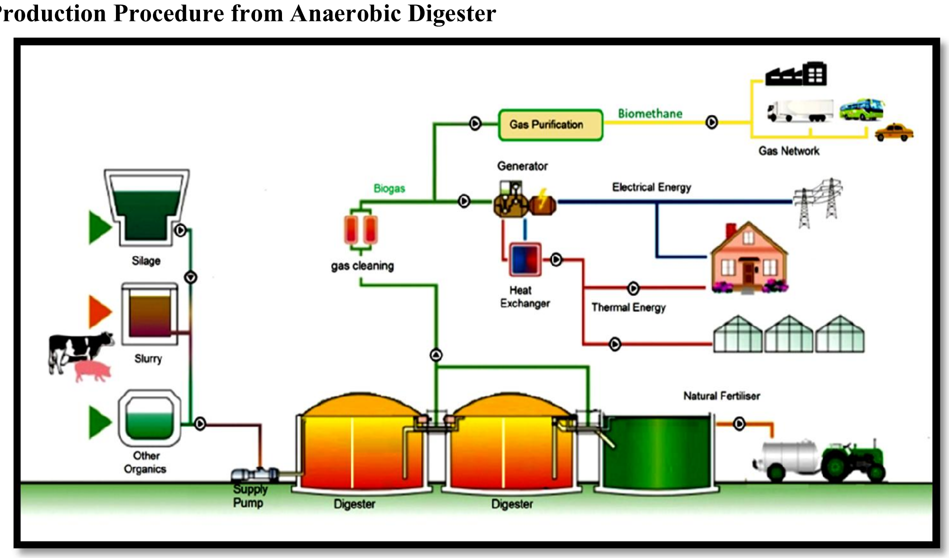

Figure 5: Biogas production procedure from anaerobic digester

The anaerobic digestion process is divided into three stages. The first stage is to use hydrolysis to coagulate granular feedstock material. The soluble solids that resulting from hydrolysis are then digested in the second stage. Acid-producing anaerobic bacteria do this process at the molecular level (primarily acetic, propionic, and butyric acid). The microorganisms engaged in this step are organisms that can both utilise oxygen and produce energy anaerobically. These organisms can survive in a wide range of pH conditions.[24]Gasification is the final and most time-consuming process. Certain bacteria employ the organic acid generated in the second phase as a substrate, resulting in the production of methane and carbon dioxide emissions. Methanogenesis is the name given to the process that results in the creation of methane. [25] Biogas is composed mostly of methane and carbon dioxide, with trace quantities of hydrogen sulphide and other gases. After the biogas is created, it is sent through a series of scrubbers and upgrading equipment to remove any remaining greenhouse gases. PSA (pressure swing adsorption) units or membrane filters are common gas upgrading technologies that are being used to improve gas to pipeline quality requirements and remove greenhouse gases.[26]

Anaerobic digesters are impermeable tanks that run at a temperature of 95°F to 105°F or 135°F to 145°F. Covered lagoon, plug flow, and full mix are three common types of anaerobic digesters. Fixed film, induced blanket, and two-phase digesters are less frequent digester types. Which method is acceptable depends on the properties of the manure, how it is handled, and whether or not bedding is used? Manure may be co-digested based on digester technology.[27]

Mixing is sporadic in standard digesters, and holding durations can range from 30 to 60 days, resulting in sludge formation and reduced gas output. Due to constant mixing as well as a more effective sludge feeding and removal mechanism, modern digesters have better turnover and digestion rates. Modern digesters may retain food for as little as 15 days or fewer.[28].

A. Throughput Products and By Products

Many value-added products may be produced by anaerobic digestion. Biogas may be used to create power or fuel a boiler, and it can be improved to meet renewable natural gas requirements by removing contaminants. Biogas that has been enhanced can indeed be put into the natural gas transmission or utilised as a car fuel on farms. A solid-liquid evaporator can separate digestate into a polymer solution (filtrate) and a heterogeneous structure (fibre) for use as a nutrition source on the ground.[29]

The supernatant can be utilised as fertiliser or processed even more to fulfil effluent quality criteria. A commercial dairy mix digester may generate 30 pounds of nitrogen, 10 pounds of phosphate, and 30 pounds of potash every 1,000 gallons of liquid digestate (filtrate). The nutritional analysis will vary based on the digester's management, the feedstocks employed, and other variables. The solid fraction's fibre can be used as a soil supplement, livestock bedding, or compost feedstock, or it can be utilised to create medium-density fibre board. These are just a few of the value-added alternatives that may be used with a digester.[30]

5.5. Factors Affecting Biogas Production

A. Carbon to Nitrogen Ratio

Carbon(C) and nitrogen(N) are two important nutrients for species development and nutrient elimination (N). The carbon to nitrogen ratio must be kept between 20 and 30 for efficient anaerobic digestion.[31]. Ammonia builds up in the digester as a result of a decreased C:N ratio, which limits microorganism activity. Lower gas output is caused by a higher C:N ratio. Different types of material are mixed together to maintain the appropriate C:N ratio of the influent feed. Numerous different materials are mixed together in the influent feed. The microbial community engaged in aerobic digestion need enough resources to grow in a predictable manner. If the C/N ratio is too high, the method is governed by N availability, and the resulting acidification slows methanogenesis activity; if it is too low, ammonia may be found in abundances large enough to be toxic to the bacterial population.[32]

B. Temperature

Fermentation temperature has a significant impact on biogas generation. The optimum conditions for anaerobic fermentation and methane-forming bacteria are temperatures of 29°C to 41°C or 49°C to 60°C, with a pressure of 1.1 to 1.2 bar absolute. This is because two distinct types of bacteria reproduce best in these two temperature ranges, yet the high-temperature bacteria are far more susceptible to environmental effects. The rate of gas production increases as the temperature rises, but the percentage of methane produced decreases. Temperatures between 32°C and 35°C have been shown to be the most efficient for producing methane in a steady and continuous manner.[33]

C. pH Value

Because methane formers are acidic, a pH of more than 7.0 is maintained during the methane production stage. According to McCarty, the optimal pH range for anaerobic treatment is about 7.0-7.2, although it can also work effectively at pH levels ranging from 6.6 to 7.6. In terms of chemical makeup, organic materials differ from one another. That mixture may not always be ideal for optimal bacterial growth and methane generation.[34]. Lactose, for example, the significant aspect of whey solids, encourages the development of acid-producing bacteria under anaerobic environments. Lactose is broken down by these bacteria into short-chain fatty acids like acetic, propionic, butyric, and other acids, causing a fast drop in medium ph. Reduced pH has a detrimental impact on methane-producing bacteria, resulting in low biogas production.[35]

D. Hydraulic Retention Time, in (days), HRT

The average amount of time a soluble chemical remains in a built bioreactor is measured by hydraulic retention time, also known as hydraulic residence time. The capacity of the sedimentation tanks split by the prominent fluid velocity equals hydraulic retention time.[36]

$$HRT\ [d] = \frac{\text{volume of aeration tank [m3]}}{\text{Influent flow rate [m3/ d]}}$$

Where, HRT is hydraulic retention time (d) and usually expressed in hours (or sometimes days), the V is the volume of aeration tank or reactor volume (m3), and Q is the influent flow rate (m3 /d). The hydraulic retention time is the amount of time that the substrate and the components that are being removed keep in interaction with the biomass within the reactor.[37]

E. Organic Loading Rate

On anaerobic treatment systems, the volumetric Organic Loading Rate (OLR) is proportional to the retention time via loading [38].The organic loading rate is significant in anaerobic wastewater treatment. Because the chemical oxygen demand (COD) is commonly employed to determine the amount of organic matter in wastewater, the OLR for biological systems is expressed as COD per reactor volume per unit time (i.e., kg COD/m3.day[39].The OLR may be changed by altering the permeate proportion and the flow rate. As a result of altering the HRT and the fluid velocity, OLR can be represented in the following ways under these conditions.

$$OLR = \frac{Q*COD}{V}$$

Where, OLR is organic loading rate (kg COD/m3·d), Q is flow rate (m3/d) COD is chemical oxygen demand (kg COD/m3/d), COD is chemical oxygen demand (kg COD/m3), and V is reactor volume (m3)[40].

F. Alkalinity

Alkalinity refers to the digestive medium's capacity to absorb protons or neutralise overly acidic or basic conditions. The power of water to neutralise acid is known as alkalinity[41] .The typical proportion of carbon dioxide in the gas phase of anaerobic digestion is 25–45%. A pH greater than 6.5 necessitates bicarbonate alkalinity of at least 500–900 mg/L CaCO3. When adequate carbonate buffering is not present in the wastewater, alkaline materials are added to keep the pH in the acceptable range for anaerobic digestion[42].

5.6. Merits of Biogas

Biogas is a sustainable and clean form of energy, Biogas is a sustainable and environmentally friendly energy source that helps to reduce greenhouse gas emissions, Biogas does not pollute the environment, Biogas production helps to clean up the environment by lowering pollution, Organic fertiliser is produced via biogas production, it's a low-cost, low-tech solution that promotes a circular economy and for underdeveloped regions, a healthy cooking option.[43][44]

5.7. Disadvantages of Biogas

Currently, the biogas generation system is inefficient, impurities remain in biogas after it has been refined and compressed, weather has an impact on biogas production[45] Although bacteria require a temperature of about 37°C to digest garbage, digesters in cold areas require heat energy to ensure a consistent biogas supply and unsuitable for densely populated urban regions [46][47]

VI. Future Aspects

A new approach using an open-source low- cost system for monitoring and controlling biogas production from the dairy industry may be expected in the future: a system to monitor/control was developed, the use of low-cost electronic components and Arduino was efficient for the process monitoring, the digestion of dairy waste inoculated with sewage sludge was performed, COD removal and biogas production took place in the An STBR and digestate analysis showed higher toxicity.

VII. Conclusion

Anaerobic treatment is a tried-and-true method for producing biogas (methane), which can be used to generate renewable heat and power as well as compact output. Temperature, pH, organic loading rate, sludge retention time, hydraulic retention time, up flow velocity, and size distribution all have a significant impact on anaerobic treatment efficiency. Therefore, anaerobic treatment needs especially kind of setting because anaerobic processes successfulness depends on bacteria living and growth inside the reactor and the investigated results show that biogas is the cheapest non- conventional energy source produced through an engineered way from dairy industry wastewater.

References

[1]. Srinivasan G.,2009, “A Study on Dairy Wastewater Using Fixed-Film Fixed Bed Anaerobic Diphasic Digester” American-Eurasian Journal of Scientific Research 4 (2): 89-92.

[2]. GotmareMonali, R.M.Dhoble, A.P.Pittule, “Biomethanation of Dairy Waste Water Through UASB at Mesophilic Temperature Range” (IJAEST @2011, Vol.8 Issue 1, 001-009.

[3]. Ramesh T. “Performance evaluation of fixed Bed fixed film anaerobic Bioreactor for treating dairy effluent” Jr. of Industrial Pollution Control 23 (1)(2007) pp 11-14

[4]. Deshannavar U. B., Basavaraj (2012), High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor, Journal of Chemical and Pharmaceutical Research, 4(6):2895-2899

[5]. Nattushrirame ,Environmental engineer,2017).

[6]. Arthur.R, Baido.M.K and Antwi.E (2011), “Biogas as a potential renewable energy source”, a Ghanian case study, Renewable energy, vol.36, pp.1510-1516.

[7]. M.N. Rao and A.K. Datta (2012).,” waste water treatment “, third edition.pp.254-258)

[8]. Tawfika A, Sobheyb m, badwya M. trearment of a combined dairynand domestic wastewater in an upflow anaerobic sludge blanket reactor followed by activated sludge (as system). Desalination .2008;227(1-3) : 167 -`177.DOI :10.116/j.desel.2007.06.023.

[9]. Taneryonar,ozgesivrioglu and nihanozengin , physio -chemical treatment of dairy industrial waste water.

[10]. Deshannavar U. B., Basavaraj. R. K (2012), High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor, Journal of Chemical and Pharmaceutical Research, 4(6):2895-2899

[11]. M. Naik (2012), High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor, Journal of Chemical and Pharmaceutical Research, 4(6):2895-2899

[12]. Bhuyar Er. Kiran D., 2013,“Treatment of domestic wastewater in an up flow anaerobic packed bed reactor (UAPBR)” International Journal of AdvancedEngineering Research and Studies, E-ISSN2249–8974, IJAERS /Vol. II/ Issue III/April-June, /122-124, Research Paper

[13]. SorathiaHarilal S., Dr. Pravin P. Rathod, Arvind S. Sorathiya, “Bio-gasgeneration and factors affecting the bio-gas generation – a review study” International Journal of Advanced Engineering Technology E-ISSN 0976-3945, IJAET/Vol.III/ Issue III/July-Sept, 2012/72-78

[14]. Arthur.R, Baido.M.K and Antwi.E (2011), "Biogas as a potential renewable energy source", a Ghanian case study, Renewable energy, vol.36, pp.1510-1516.
[15]. Chelliapan., S Sallis., P.J (2011), "Performance of an up-flow anaerobic packed bed reactor system treating pharmaceutical wastewater" IPCBEE vol.1 (2011) © IACSIT Press, Singapore.
[16]. Dioha I. J., C.H. Ikeme, T. Nafi'u, N. I. Soba and Yusuf M.B.S., September2013, "Effect of carbon to nitrogen ratio on biogas production", InternationalResearch Journal of Natural Sciences, Vol. 1 No. 3, pp.1 -10.
[17]. Chaudhary Binod Kumar, 2008, "Dry continuous anaerobic digestion of municipal solid waste in thermophilic conditions" A thesis submitted in partialfulfillment of the requirements for the degree of Master of Engineering in Environmental Engineering and Management Asian Institute of Technology, School of Environment, Resources and Development, Thailand .
[18]. Demirel.B and Yenigun.O (2004), "Anaerobic acidogenesis of dairy wastewater, the effects of variations in hydraulic retention time with no pH control".
[19]. Bhadouria, BS and Sai, VS 2011, "Utilization and treatment of dairy effluent through biogas generation- a case study", International Journal of Environment Science, vol.1.
[20]. A.P.Pittule, "Biomethanation of Dairy Waste Water Through UASB at Mesophilic Temperature Range" (IJAEST @2011, Vol.8 Issue 1, 001-009.
[21]. GotmareMonali,"Biomethanation of Dairy Waste Water Through UASB at Mesophilic Temperature Range" (IJAEST @2011, Vol.8 Issue 1, 001-009.
[22]. Gotmare.M, Dhoble, RM and Pittule, AP (2011), "Biomethanation of dairy wastewater through UASB at mesophilic temperature range", Engineering sciences, no.8, pp.1-9.
[23]. Onyimba IA and Nwaukwu IA " Generation of biogas from cow dung".
[24]. J. Lebrator, J.L.PérezRodríguezr, "Cheese factory wastewater treatment by anaerobic semicontinuous digestion" Resources, Conservation and Recycling, 3 (1990) 193-199, Elsevier Science Publishers B.V./Pergamon Press plc-Printed in The Netherlands, 193, Instituto de Ciencia de Materiales, C.S.I.C., Aptdo. 1052, 4,1080 Sevilla (Spain).
[25]. C. Maqueda and E. Morillo, "Cheese factory wastewater treatment by anaerobic semicontinuous digestion" Resources, Conservation and Recycling, 3 (1990) 193-199, Elsevier Science Publishers B.V./Pergamon Press plc-Printed in The Netherlands, 193, Instituto de Ciencia de Materiales, C.S.I.C., Aptdo. 1052, 4,1080 Sevilla (Spain).
[26]. Srinivasan G., R. Subramaniam and V. Nehru kumar (2009),"A Study on Dairy Wastewater Using Fixed-Film Fixed Bed Anaerobic Diphasic Digester" American-Eurasian Journal of Scientific Research 4 (2): 89-92.
[27]. T. Ramesh, V. Nehru kumar and G. Srinivasan (2012), "Kinetic Evaluation of Fixed Film Fixed Bed Anaerobic Reactor by Using Dairy Wastewater" International Journal of Pharmaceutical & Biological Archive; 3(4):835-837.
[28]. Deshannavar, UB, Basvaraj, RK and Naik, NM (2012), "High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor", Journal of chemical and Pharmaceutical Research, vol.4, no.6, pp.2895-2899.
[29]. Javed Iqbal Qazi, Muhammad Nadeem, ShaguftaS.Baig,(2011), "Anaerobic fixed film biotreatment of dairy wastewater", Middle-East Journal of Scientific Research 8(3): 590-593, 2011, ISSN 1990- 9233.
[30]. Shahjahan Baig and Quartulain Syed (2011), "Anaerobic fixed film biotreatment of dairy wastewater", Middle-East Journal of Scientific Research 8(3): 590-593, 2011, ISSN 1990- 9233.
[31]. Perera K.U.C., "Investigation of Operating Conditions for Optimum Biogas Production in Plug Flow Type Reactor" Master of Science Thesis, KTH School of Industrial Engineering and Management, Energy Technology EGI2009-2011 Division of xxx, SE-100 44 Stockholm.
[32]. Dioha I. J., C.H. Ikeme, T. Nafi'u, N. I. Soba and Yusuf M.B.S., September2013, "Effect of carbon to nitrogen ratio on biogas production", InternationalResearch Journal of Natural Sciences, Vol. 1 No. 3, pp.1 -10
[33]. Perera K.U.C., "Investigation of Operating Conditions for Optimum Biogas Production in Plug Flow Type Reactor" Master of Science Thesis, KTH School of Industrial Engineering and Management, Energy Technology EGI2009-2011 Division of xxx, SE-100 44 Stockholm.
[34]. Asha B., June 2014, "Influence of pH condition on the performance of fixed film fixed bed reactor in dairy wastewater" Direct Research Journal of Engineering and Information Technology (DRJEIT) Vol.2 (3), pp. 33-36.
[35]. Demirel.B and Yenigun.O (2004), "Anaerobic acidogenesis of dairy wastewater, the effects of variations in hydraulic retention time with no pH control".

[36]. Rajeshwari K.V., M. Balakrishnan, A. Kansal, Kusum Lata,V.V.N. Kishore(2000), "State-of-the-art of anaerobic digestion technology for industrial wastewater treatment", Renewable and Sustainable Energy Reviews, 4, 135±156,www.elsevier.com/locate/rse.

[37]. AbdelgadirAwad, Xiaoguang Chen, Jianshe Liu, XuehuiXie, Jian Zhang, Kai Zhang, HengWang, and Na Liu, "Characteristics, Process Parameters, and Inner Components of Anaerobic Bioreactors" Hindawi Publishing Corporation, BioMed Research International Volume 2014, Article ID 841573.

[38]. A. O. Adebayo, S. O. Jekayinfa and B. Linke, 2015 , "Effects of Organic Loading Rate on Biogas Yield in a Continuously Stirred Tank Reactor Experiment at Mesophilic Temperature" British Journal of Applied Science & Technology, 11(4): 1-9

[39]. Tabatabaei Meisam, Alawi Sulaiman, Ali M. Nikbakht, NorjanYusof and GhasemNajafpour (2011). "Influential Parameters on Biomethane Generation in Anaerobic Wastewater Treatment Plants, Alternative Fuel", pp. 227-263

[40]. T. Ramesh, V. Nehru kumar and G. Srinivasan (2012), "Kinetic Evaluation of Fixed Film Fixed Bed Anaerobic Reactor by Using Dairy Wastewater" International Journal of Pharmaceutical & Biological Archive; 3(4):835-837

[41]. Sivakumar M.S. and B. Asha, "Effect of organic loading rate on dairy wastewater using anaerobic bio-film reactor" Jr. of Industrial Pollution Control 28(1)(2012) pp 21-24, © EM International Printed in India.

[42]. S. Karthiyayini, A. Sivabharathy, C. Sreehari, M. Sreepoorani& V. Vinjth, "Production of Biogas From Dairy Waste Water", International Journal of Engineering Research and Modern Education, Special Issue, April, Page Number 131-134, 2017.

[43]. Bhadouria, BS and Sai, VS 2011, "Utilization and treatment of dairy effluent through biogas generation- a case study", International Journal of Environment Science, vol.1.

[44]. Despande D.P, Patil P.J and Anekar S.V (April 2012), "Biomethanation of dairy waste, Research Journal of Chemical Sciences, ISSN 2231-606X,vol.2(4),35-39.

[45]. [Jactone.A.O, Wen.Z, Ignosh.J, Bendfeldt.E and Collins, E.R (2009), "Biomethane Technology", Virginia cooperative extension publication, vol.3, pp.442-881.

[46]. Kolhe AS and Pawar, VP (2011), "Physico- chemical analysis of effluents from dairy industry", Recent research in science and technology, vol.3, no.5, pp 29-32.

[47]. Gavala.H.N, Kopsinis.H, Skiadas I.V, Stamatelaton.K, Liberatos.G, (1999), "Treatment of dairy wastewater using upflow anaerobic sludge blanket reactor", Journal of Agricultural Engineering Research, vol.73, no.1, pp.59-63.