International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Research Article

Anaerobic Reactor to Treat Dairy Industry Wastewater

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Accepted 05 September 2013, Available online 01 October 2013, **Vol.3, No.4 (October 2013)**

Abstract

Dairy industry is one of the major food industries in India, and India ranks first among the maximum major milk producing nation. Of these, about 50% of the units are yet to attain satisfactory performance level with regard to installation and operation of effluent treatment plants. These wastewaters, if discharged without proper treatment severely pollute receiving water bodies. To treat these wastewaters combined with alternate energy source, environmentalists are developing a high rate anaerobic reactor. To minimize the economical burden of treatment on industrialist, having low cost anaerobic reactor with alternate energy source serves the best option. This paper reviews in brief the essential information on the fundamentals of anaerobic reactor treatment as well as technology. Also, it focuses on various anaerobic reactor configurations and operating conditions used for the treatment of dairy industry wastewaters so as to produce alternate energy source as BIO-GAS.

***Keywords** : Dairy industry, Fixed bed Reactor, Anaerobic Reactor, Anaerobic Digestion, Wastewater*

1. Introduction

Increasing industrialization trend in the worldwide has resulted in the generation of industrial effluents in large quantities with high organic content, which if treated appropriately, can result in a significant 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. Anaerobic digestion seems to be the most suitable option for the treatment of high strength organic effluents. Anaerobic technology has improved significantly in the last few decades with the applications of differently configured high rate treatment processes, especially for the treatment of industrial wastewaters. 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. These reactors, known as second generation reactors or high rate digesters, can handle wastes at a high organic loading rate of 24 kg COD/m^3 day and high up flow velocity of 2-3 m/h at a low hydraulic retention time. High organic loading rates can be achieved at smaller footprints by using high rate anaerobic reactors for the treatment of industrial effluents.

An anaerobic process is a process where organic matters in wastewaters are converted to methane and carbon dioxide through a series of reactions involving a consortium of obligate and facultative anaerobic microorganisms. Anaerobic systems can be categorized according to how the biomass is retained in the system and type of biomass they depend on. Systems where the bacteria grow and are suspended in the reactor liquid are called suspended-growth processes. In the suspended growth process, the microorganisms in suspension have more intimate contact with the substrates. Typically, suspended-growth systems have sludge that is considered to be flocculent or granular in nature-oftentimes both flocculent and granular sludge coexist in a reactor. Granular sludge exhibits high activity rates and settling velocities that reduce required reactor volumes and increase allowable organic loading rates. (Dahlan et al, 2013)

In the attached growth process, micro-organisms are immobilized on a support surface, forming biofilms. Substrates in the wastewater are adsorbed into the film and gradually degraded by the microorganisms. The attached growth process seems to be more stable than suspended growth process when the wastewater has considerable fluctuations in flow rate and concentrations. Limitation of mass transfer can effectively shield the micro-organisms from the shock loadings of substrates and toxins. Furthermore, even if the growth rate of biomass is reduced by adverse condition, the population of micro-organisms can still be maintained since they are physically retained in the system. The utilization of fixed films for wastewater treatment process has been increasingly considered due to

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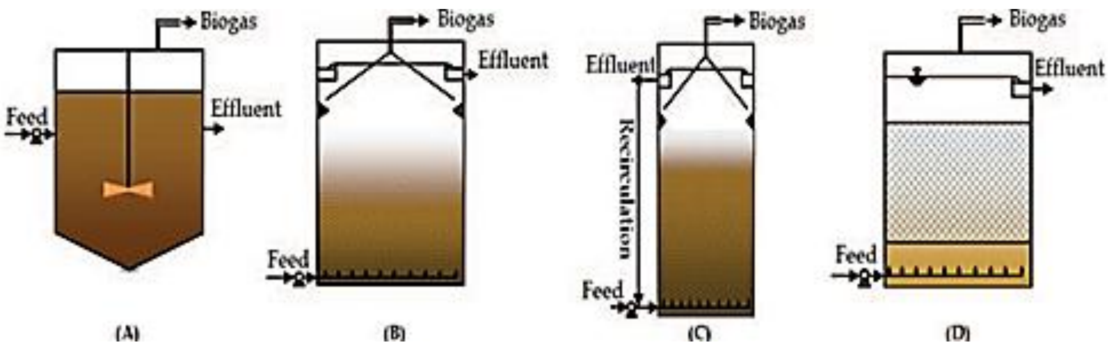

Fig. 1 Most commonly used anaerobic reactor types: (A) Completely mixed anaerobic digester, (B) UASB reactor, (C) AFB or EGSB reactor, (D) Upflow AF

inherent advantages over suspended growth system. One of the advantages is high biomass per reactor volume which permits higher organic loading rate, short liquid detention times and good performance stability.

2. Reactor Types

The most common types of the reactor configurations used for the anaerobic treatment of industrial wastes are discussed here and illustrated in Fig. 1 shown above. (Mustafa Evren Ersahin et. al., 2011)

Anaerobic reactors can be divided into conventional AD or high rate AD. High rate anaerobic reactors include completely mixed anaerobic digester, anaerobic contact process, anaerobic sequencing batch reactor (ASBR), anaerobic packed bed or anaerobic filter, anaerobic fluidized and expanded bed reactors, upflow anaerobic sludge blanket (UASB) reactor. Anaerobic packed bed reactor were first proposed as a treatment process by Young and McCarty and is similar to a trickling filter biomass is attached on inert support material in biofilm form. The material can be arranged in various confirmations, made out of different matter (plastics, granular activated carbon (GAC), sand reticulated foam polymers, granite, quartz and stone) and can be packed in two configurations (loose or modular). The reactors can be operated in up-flow or down-flow feed mode. (Dahlan et al, 2013)

2.1 Anaerobic contact process

Link between high biomass concentration, greater efficiency and smaller reactor size is the idea of Anaerobic contact process ACP as shown in Figure 2. Settling of anaerobic sludge in a settling tank and its return back to the reactor allows extra contact between biomass and raw waste. In ACP, due to sludge recycling, the SRT is no longer tied to the HRT. As a result, significant improvements in treatment efficiency can be achieved.

Major Anaerobic sequencing batch reactor (ASBR) process is a batch-fed, batch-decanted, suspended growth system and is operated in a cyclic sequence of four stages: feed, react, settle and decant. Due to significant time is spent in settling the biomass from the treated wastewater, reactor volume requirement is higher compared to continuous flow processes.

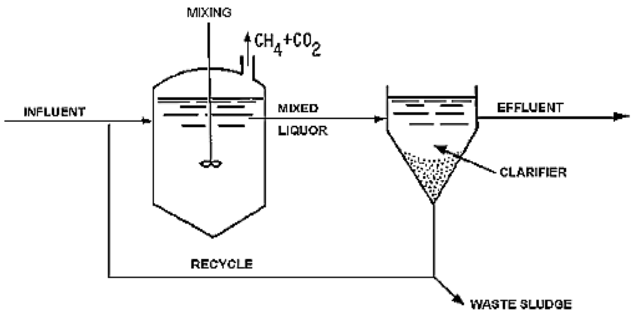

Fig. 2 Anaerobic contact process

2.2 Anaerobic Fluidized Bed Reactor

Anaerobic Fluidized Bed Reactor (AFBR) (Fig.3) is a biological reactor that accumulates a maximum active attached biomass thus far still handling fine suspended solids without blocking. By minimizing the volume occupied by the media and maximizing the surface area available for microbial attachment, a maximum specific activity of attached biomass may be achieved for a given reactor volume. A filter containing extremely small particles (0.5 mm) provides sufficient surface area to achieve these benefits.

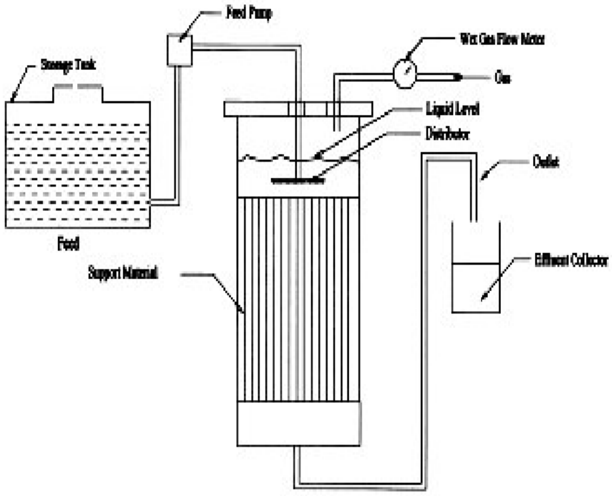

Fig.3 Anaerobic fluidized bed (AFB) reactor

The anaerobic fluidized bed (AFB) reactor comprises small media, such as sand or granular activated carbon, to which bacteria attach. Good mass transfer resulting from the high flow rate around the particles, less clogging and short-circuiting due to the large pore spaces formed through bed expansion and high specific surface area of the carriers due to their small size make fluidized bed reactors highly efficient. However, difficulty in developing strongly attached biofilm containing the correct blend of methanogens, detachment risks of microorganisms, negative effects of the dilution near the inlet as a result of high recycle rate and high energy costs due to the high recycle rate are the main drawbacks of this system. The expanded granular sludge bed (EGSB) reactor is a modification of the AFB reactor with a difference in the fluid's upward flow velocity. The upflow velocity is not as high as in the fluidized bed which results in partial bed fluidization. (Mustafa Evren Ersahin, et al, 2011)

2.3 Upflow Anaerobic Sludge Blanket Reactor

In 1970s, the concept of an unpacked high-rate reactor called UASB reactor was developed. It is considered as the most widely used high-rate anaerobic system for industrial and domestic wastewater treatment worldwide. In UASB reactor, sufficient mixing is provided by an even flow-distribution combined with a sufficiently high upflow velocity, and by agitation that results from gas production. Biomass is retained as granular matrix or blanket, and is kept in suspension by controlling the upflow velocity. Wastewater flows upwards through a sludge blanket located in lower part of reactor, while upper part contains a three phase separation system, which are the most characteristic feature of UASB reactor (Figure 4).

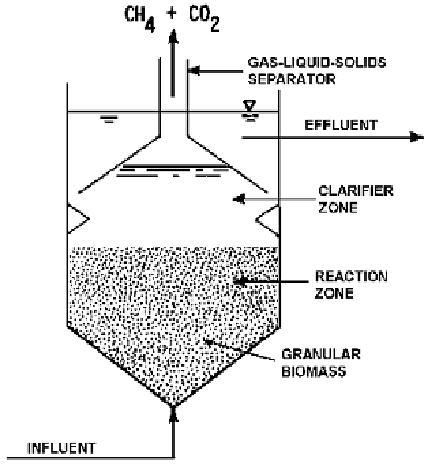

Fig. 4 Upflow Anaerobic Sludge Blanket Reactor

A UASB reactor (fig. 4) essentially consists of gas-solids separator (to retain the anaerobic sludge within the reactor), an influent distribution system and effluent draw off facilities.

It contributes the collection of biogas and also provides internal recycling of sludge by disengaging adherent biogas bubbles from raising the sludge particles. An advanced settling characteristic of granular sludge allows higher sludge concentrations and consequently permitted UASB reactor to achieve much higher OLRs. Granular sludge development is now observed in UASB reactors treating different types of wastewater.

2.4 Anaerobic filter

Anaerobic filter (Fig.5) is a fixed-film biological wastewater treatment process where fixed matrix (support medium) provides an attachment surface that supports the anaerobic microorganisms in the form of a biofilm. As wastewater flows upwards through this bed and dissolved pollutants are absorbed by biofilm, treatment occurs. Anaerobic filters were the first anaerobic systems that eliminated the need for recycle and solids separation while providing a high SRT/HRT ratio. Various types of support material can be used, such as sand, plastics, gravels, reticulated foam polymers, stone, granite, granular activated carbon (GAC), and quartz.

The anaerobic filter (AF) has been widely applied in the beverage, food-processing, pharmaceutical and chemical industries due to its high capability of biosolids retention. In fact clogging by biosolids, influent suspended solids, and precipitated minerals is the main problem for this system. Applications of both upflow and downflow packed bed processes can be observed.

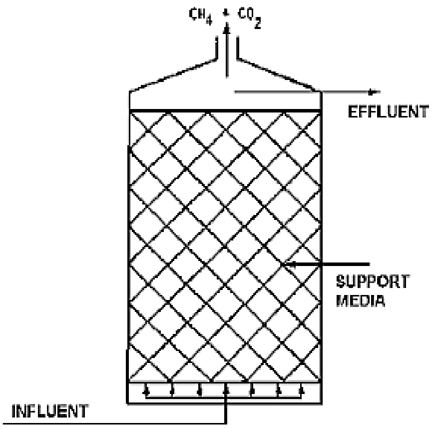

Fig.5: Anaerobic filter

3. Literature Review

3.1 Upflow Anaerobic Sludge Blanket Reactor

According to A. Tawfika et.al.[2008] the up-flow anaerobic sludge blanket (UASB) reactor is an efficient technique for pre-treatment of dairy and domestic wastewater (DDWW) at an average wastewater temperature of 20^0C and a HRT of 24 h. The reactor achieved percentage removal values of 69% for COD total, 79% for BOD and 72% for TSS. He used the UASB reactor as shown in fig.6.

He used the laboratory-scale UASB reactor (5.0 l) consisting of a cylindrical column with a conical shaped bottom and gas solid separator (GSS). The UASB reactor has a height of 70 cm, and an internal diameter of 10 cm. Ports for obtaining sludge samples are arranged along the reactor height, the first one at 5.0 cm above the base of the reactor and the others at 15, 25, 40 and 55 cm.

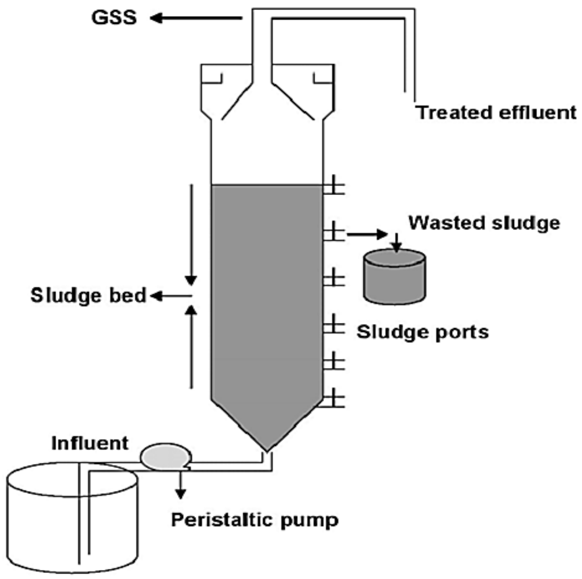

Fig. 6 Schematic diagram of the UASB reactor treating DDWW

According to him, the UASB reactor has become the most widely applied reactor technology for treatment of dairy wastewater, because the UASB reactor has relatively high treatment capacity compared to other systems which is due to its compact size and cost effectiveness.
Monali Gotmare et.al [2011] has also studied a UASB reactor (Fig. 7) for treating dairy wastewater.

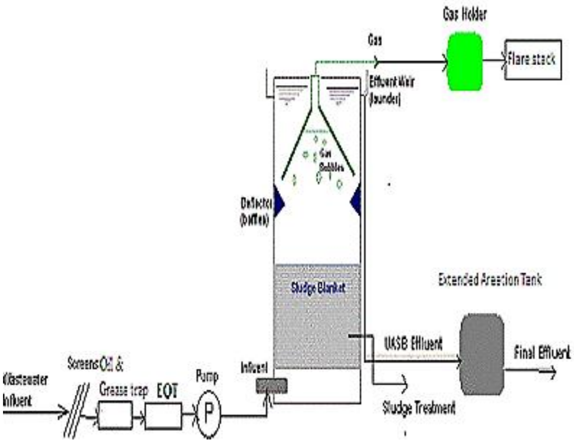

Fig. 7 UASB reactor

The UASB reactor used in this study was made up of R.C.C. The working volume of the reactor was 120.12 m^3. The reactor consisted of five sampling ports; one inlet, which was further diverged into four channels; one effluent outlet; two gas outlets and a gas-solid-liquid separator. The feed loading rates were controlled with peristaltic pumps. He found that reactor achieved COD, BOD, TSS removal efficiency was observed 87.06%, 94.50%, and 56.54% respectively. The average gas production and methane gas conversion at optimum conditions was observed to be 179.35m^3/day and 125.55 m^3/day, respectively

3.2 Anaerobic Fixed Film reactor

J. I. Qazi et.al[2011] has studied a number of biofilm support media including foam cubes, bamboo rings, fire bricks, PVC rings and gravels to immobilize biomass for reduction in BOD_5, COD and VSS of dairy wastewater in batch and repeated batch cultivation system in Anaerobic Fixed Film Biotreatment. Eventually, he found that the maximum percentage removal of COD, BOD and VSS turned out to be as 96%, 93% and 90%, respectively, with the application of 21 Kg COD/m^3/d loading in batch reactor filled with gravels. He used the Fixed Film reactor as shown in fig.8

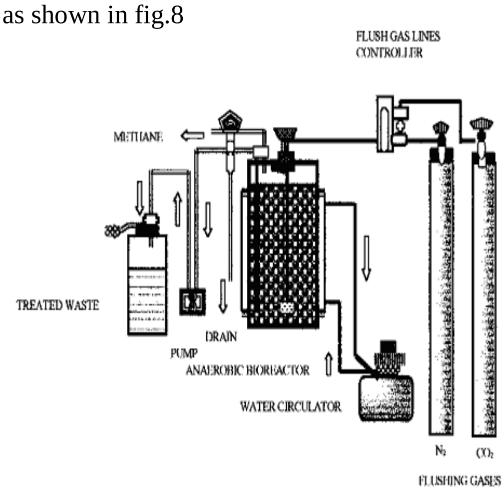

Fig. 8 Schematic diagram of Anaerobic Bio-treatment System

3.3 Upflow anaerobic packed bed bioreactor

Deshpande D. P. et. al. [2012], have used the pilot scale Upflow anaerobic packed bed bioreactor (UAPB) (Fig. 9) with an internal diameter of 20cm and a height of 45 cm using seashell as a packing material for dairy wastewater treatment. The total volume of reactor was 30 lit. The void volume of the packed reactor was 65%. A 1000 ml funnel shaped gas separator was used to liberate the generated biogas from the effluent, and then the gas was led to the gas collector tank.

He used the UAPB not only for treatment but he proved that with the help of UAPB dairy industry effluent is very good raw material for production of methane gas, commercially known as BIO-GAS, which can be use as a fuel and can replace the other fuel and COD value also decreases from 71526 mg/lit to 42200 mg/lit as the time increases from first day to the 56th day of the experiment. As the process of anaerobic digestion is slow process still it have the biggest advantage of production of methane and also this process reduces the COD of the effluent.

G. D. Najafpour, et.al [2009] also used the same Upflow anaerobic packed bed bioreactor (UAPB) (Fig. 9) to treat Dairy Wastewater. The Plexiglass reactor column was fabricated with an internal diameter of 19.4 cm and a height of 60 cm. The total volume of the reactor was 17.667 L. The column was packed with a seashell that as shown in Figure 9. The void volume of the packed bed reactor was 65%. With this, he found that high COD and

Lactose removals of 94.5 and 99% at HRT of 16 h having highest yield of methane production and the maximum biogas volumetric production.

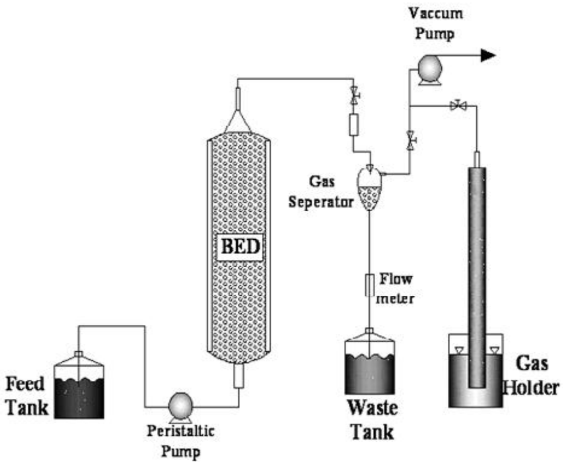

Fig. 9 Upflow anaerobic packed bed bioreactor

3.4 Upflow Anaerobic Sludge-Fixed Film Bioreactor

At the same time, G.D. Najafpour, et.al [2008] have used Upflow Anaerobic Sludge-Fixed Film (UASFF) Bioreactor for the Treatment of Dairy Wastewater. (Fig. 10) UASFF bioreactor was developed with tubular flow behavior in order to shorten the start-up period of UASB reactor at low HRT. The column was randomly packed with seashell.

The reactor was fabricated with an internal diameter of 2.76 cm and a height of 160 cm. The total volume of the reactor was 960 ml. The column was randomly packed with seashell. The voidage of the packed bed reactor was 85 percent. A 1000ml funnel shaped gas separator was used to liberate the generated biogas from the effluent and then the gas was led to the gas collector.

In this experiment, at HRT 48 h and temperature 36°C he found that, the COD removal rate and lactose conversion of 97.5 and 98 percent respectively. The highest biogas rate of 3.75 l/d was achieved at HRT of 36 h.

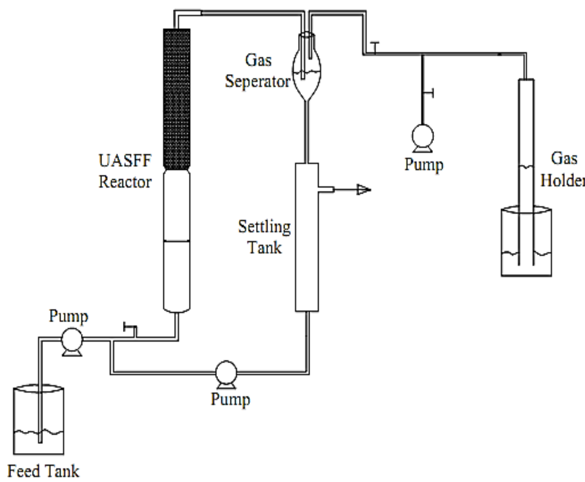

Fig.10 Schematic diagram of Upflow Anaerobic Sludge-Fixed Film (UASFF) Bioreactor

3.5 Upflow Anaerobic Fixed bed Fixed Film Bioreactor

U. B. Deshannavar et. al. [2012], have used laboratory scale upflow anaerobic fixed-bed reactor as shown in fig. 11 for the treatment of dairy effluent.

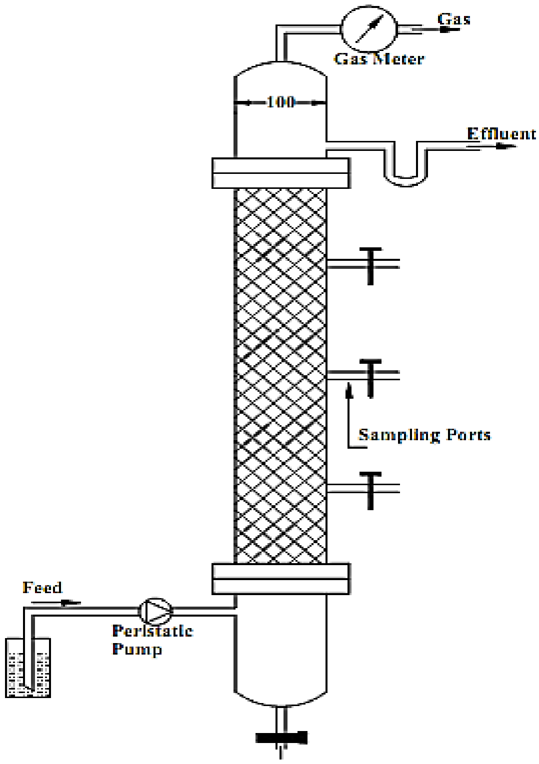

Fig. 11 Schematic diagram of Upflow anaerobic fixed-bed reactor

An upflow anaerobic fixed-bed reactor was fabricated using PVC pipes and fittings. The internal diameter of the pipe is 10 cm and height 125 cm. A dispersion plate of 4 cm thick, 15 cm in diameter having 120 holes each of 0.6 cm diameters has been provided at the bottom of the reactor to support the packing media, as well as to ensure proper distribution of influent through the packing media. The reactor was packed with polypropylene pall rings as packing media. The inlet for the effluent is provided near the bottom of the reactor and the outlet near the top of the reactor. An outlet is also provided on the top of the reactor for collection of gas.

It was observed that the anaerobic filter can be effectively used for the treatment of dairy effluent at the lower HRT of 12 hours, at OLR of 5.4 kg COD/m^3/d with COD removal efficiency of 87%. The biogas production rate was 9.8 l/d. The biogas with high methane content (77%) produced due to the conversion of organics can be an alternative source of energy for the dairy industry itself.
G. Srinivasan et.al [2009] have carried out experiments on Anaerobic Diphasic Fixed Film Fixed Bed (FFFB) digester having effective reactor volume of 0.03843m^3 (38.00 lit) as shown in fig. 12 in the treatment of a synthetic dairy wastewater in order to reduce the COD of dairy waste water and for the production of biogas. They have reported maximum removal of COD as 70.40 % at a

flow rate of 0.006 m^3/day for an overall OLR of 1.265 Kg COD/m^3.day giving a maximum yield of bio-gas at 0.330 m^3 of gas / kg COD removed.

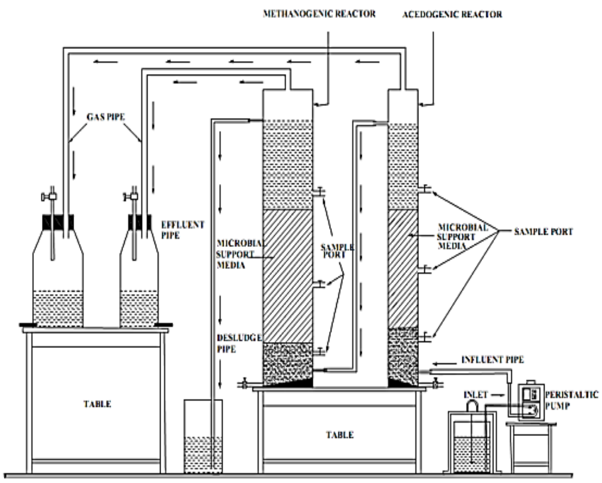

Fig. 12 Fixed Film Fixed Bed Anaerobic Reactor

T. Ramesh et.al [2012] have used the same type of fixed Bed Fixed Film anaerobic reactor (FBFFR) for treating Dairy wastewater consisting of experimental setup having 42.70 liters of effective volume having internal diameter of 20 cm and a height of 200 cm. and found that, the minimum COD reduction in the reactor is 66.75% for the OLR of 0.073 k g COD/m^2/day and HLR of 0.016 m^3/m^2day. The maximum COD reduction in the reactor is 80.88% for the OLR of 0.004 kg COD/ m^2/day and HLR of 0.003 m^3/m^2.day. The maximum gas conversion ratio is 0.265 m^3 of biogas per kg of COD removed.

In my research, I would like to use the Fixed Film Fixed Bed (FFFB) anaerobic reactor with a coir and a coconut shell cover as a brush type combination which will serve as a special media at low cost and which gives the best treatment for dairy industry wastewater.

4. Microbiology Involved In Anaerobic Digestion

Anaerobic digestion is a complex multistep process in terms of chemistry and microbiology. Organic material is degraded to basic constituents, finally to methane gas under the absence of an electron acceptor such as oxygen. The basic metabolic pathway of anaerobic digestion is shown in Fig. 13. To achieve this pathway, presence of very different and closely dependent microbial populations is required. Anaerobic degradation proceeds as a chain process, in which several sequent organisms are involved. Anaerobic conversion of complex substrates requires the synergistic action of the micro-organisms involved.

The first step of the anaerobic degradation is the hydrolysis of complex organic material to its basic monomers by the hydrolytic enzymes. The simpler organics are then fermented to organic acids and hydrogen by the fermenting bacteria (acidogens). The volatile organic acids are transformed into acetate and hydrogen by the acetogenic bacteria. Archael methanogens use hydrogen and acetic acid produced by obligate hydrogen producing acetogens to convert them into methane. Methane production from acetic acid and from hydrogen and carbon dioxide is carried out by acetoclastic methanogens and hydrogenotrophic methanogens, respectively. Thermodynamic conditions play a key role in methane formation.

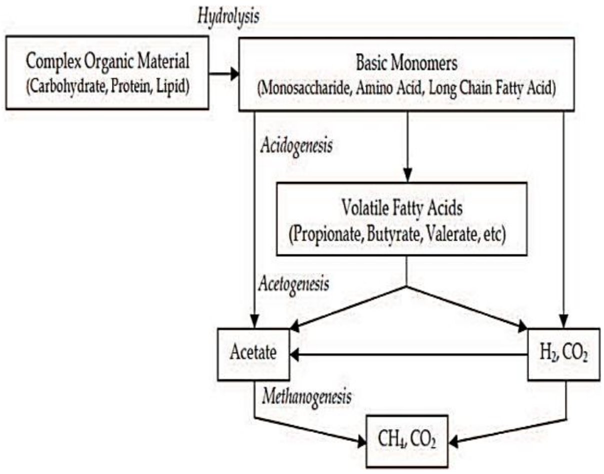

Fig.13 Metabolic pathway of anaerobic digestion

The process can be simplified as follows (actual reactions are more complex and include other sub-reactions):

Complex Organic Compounds → Fat (Organic) Acids →CH_4 + H_2O + CO_2 + Cells

It means, complex organic compounds are broken down into organic (fat) acids, and then these acids are transformed into methane, CO_2, water and anaerobic bacteria cells.

Any load changes or changes in the system's environment can disturb the dyaamic equilibriurn between the non-methanogenic and methanogenic organisms, consequently reducing the treatment efficiency of the plant. Due to the slow growth rate of the methanogenic archaea, the start-up times are considerably longer than aerobic syaems, and a longer hydraulic residence time is required for efficient biological treatment.

5. Conclusion

All design of anaerobic digester show that it is capable to treat a variety of wastewaters of varying strength. The physical structure of the reactors allows various modifications to be made that providing the capability to treat wastewaters that currently require at least two separate units, therefore substantially reducing capital costs. Anaerobic wastewater treatment is a low cost process, and is finally ready to be considered simple and reliable.

Anaerobic fixed bed reactors (AFBRs) are based on the principle of the immobilization of microorganisms on a support. This type of reactor has been successfully and widely applied for the treatment of different wastes due to its capacity for microorganism retention on the support and, therefore, the hydraulic retention time can be considerably reduced. In addition, AFBRs are easy to acclimatize and can overcome influent variations or shock loads without process failure. Moreover, the construction, operation and maintenance cost of the AFBRs are lower than those required for other high-rate reactors. The effluent of the AFBRs contains few suspended solids, eliminating the need for the separation or recycling of the solids and so the biological system recovers to the conditions present before the reactor was stopped more quickly. These characteristics make the AFBR extremely useful for the treatment of high and medium strength wastewaters.

Fixed film processes are more superior when compared to suspended processes in several aspects. Small reactor size, simple operation and high reliability make this process a cost-effective system for biological treatment. In fixed-film anaerobic reactors, large amount of biomass remains in the filter to secure solid retention despite a short hydraulic retention times. Biomass accumulation and retention in biomass systems are enhanced by attachment to a fixed medium.

The upflow anaerobic fixed-bed reactors have several advantages over aerobic and conventional anaerobic reactors such as rapid start-up with minimum operational problems; ability to withstand shock loading without significant decrease in digestion efficiency; ability to adapt intermittent feeding and rapidity of restart after lengthy shut down periods; and lower hydraulic retention times. (U. B. Deshannavar et. al., 2012) One of the advantages is high biomass per reactor volume which permits higher organic loading rate, short liquid detention times and good performance stability. (G. R. Shivakumaraswamy et. al., 2013)

References

A. Tawfika, M. Sobheyb, M. Badawya (2008), Treatment of a combined dairy and domestic wastewater in an up-flow anaerobic sludge blanket (UASB) reactor followed by activated sludge (AS system) *Desalination* 227, 167–177

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

Siti Roshayu Hassan, Haider M. Zwain, and Irvan Dahlan (2013), Development of Anaerobic Reactor for Industrial Wastewater Treatment: An Overview, Present Stage and Future Prospects,*J Adv Sci Res,* 4(1): 07-12

Deshpande D.P., Patil P.J. and Anekar S.V.(April 2012), Biomethanation of Dairy Waste, Research Journal of Chemical Sciences, Vol. 2(4), 35-39, *Res. J. Chem. Sci.*

G. D. Najafpour, M. Tajallipour, M. Komeili, and M. Mohammadi (Aug 2009), Kinetic model for an up-flow anaerobic packed bed bioreactor: Dairy wastewater treatment *African Journal of Biotechnology* Vol. 8 (15), pp. 3590-3596.

G.D. Najafpour, B.A. Hashemiyeh, M. Asadi and M.B. Ghasemi (2008), Biological Treatment of Dairy Wastewater in an Upflow Anaerobic Sludge-Fixed Film Bioreactor *American-Eurasian J. Agric. & Environ.* Sci., 4 (2): 251-257.

G. R. Shivakumaraswamy, R. M. Mahalingegowda and A. R. Vinod (2013), Domestic wastewater treatment in reactors filled with areca husk fiber and pebble bed *Elixir Pollution* 57, 14064-14066,

G. Srinivasan, 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.

Javed Iqbal Qazi, Muhammad Nadeem, Shagufta S. Baig, Shahjahan Baig and Quratulain Syed (2011), Anaerobic Fixed Film Biotreatment of Dairy Wastewater *Middle-East Journal of Scientific Research* 8 (3): 590-593, © IDOSI Publications.

K.V. Rajeshwari, 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

Medhat M. A. Saleh and Usama F. Mahmood (April 2009), UASB/EGSB Applications for Industrial Wastewater treatment *Seventh International Water Technology Conference Egypt.*

Medhat M. A. Saleh and Usama F. Mahmood (2004), Anaerobic digestion technology for industrial wastewater treatment *Eighth International Water Technology Conference, IWTC8,* Alexandria, Egypt

Monali Gotmare, R.M. Dhoble, A.P. Pittule (2011) Biomethanation of Dairy Waste Water Through UASB at Mesophilic Temperature Range , Vol.8 Issue 1, 001-009

Mustafa Evren Ersahin, Hale Ozgun, Recep Kaan Dereli and Izzet Ozturk (2011), Anaerobic Treatment of Industrial Effluents: An Overview of Applications

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

U. B. Deshannavar, Basavaraj. R. K and Nandini 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