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FEASIBILITY OF ANAEROBIC FLUIDIZED MEMBRANE BIOREACTOR (AFMBR) IN THE TREATMENT OF DAIRY WASTEWATER- A REVIEW

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ABSTRACT

The dairy industry is one of the major source of wastewater containing high concentration of organic matter and high BOD. Anaerobic treatment processes are most widely used for treating dairy wastewaters. Recent advancements in membrane technology has become promising for producing high quality effluent suitable for direct reuse. An Anaerobic-membrane combination is expected to result in better treatment efficiency. Anaerobic Fluidized Bed Membrane Bioreactor (AFMBR) is one such emerging combination with modified with granular activated carbon (GAC) fluidization to reduce membrane fouling. The aim of this review is to summarize the feasibility of the AFMBR in dairy wastewater treatment.

***Keywords*—Anaerobic Fluidized Bed Membrane Bioreactor (AFMBR), Granular activated carbon (GAC), Dairy wastewater, Wastewater treatment.**

I. INTRODUCTION

Industrialization is backbone for development of country. Due to rapid industrial growth world's economy improve with rapid growth but also that make impact in terms of pollution on environment. Pollution caused by industrial activities are serious concern throughout the world, so there exist a growing need for providing required treatment of the wastewater before discharge into the environment. .

Of all industrial activities, the food sector has one of the highest consumptions of water and is one of the biggest producers of effluent per unit of production, in addition to generating a large volume of sludge. The food industry contributes significantly to pollution, particularly as the pollutants are of organic origin. Organic pollutants normally consist of 1/3 dissolved, 1/3 colloidal and 1/3 suspended substances. The dairy industry is an example of food sector and one of a major source of waste water.

Dairy industry is one of the major food industries in India, and India ranks first among the major milk producing nation. The milk industry generates between 3.739 and 11.217 million m3 of waste per year (i.e. 1 to 3 times the volume of milk processed). The wastewater contains dissolved sugars, proteins and fat which is organic in nature and bio-degradable. Dairy wastewater is considered as high concentration of organic matter and high BOD. Untreated wastewater pollutes land and river system so that proper treatment of dairy wastewater is necessary before disposal in environment. [7]

The dairy industry is challenged with rising costs for wastewater treatment and disposal solutions. Tighter environmental restrictions coupled with rising energy and process costs limit production and expansion in many facilities. Existing water treatment systems are often loaded beyond design flows, causing inefficient operation which leads to an excessive financial burden that affects the industry’s bottom line.

In general, wastes from the dairy processing industry contain high concentrations of organic material such as proteins, carbohydrates, and lipids, high concentrations of suspended solids, high biological oxygen demand (BOD) and chemical oxygen demand (COD), high nitrogen concentrations, high suspended oil and/or grease contents, and large variations in pH, which necessitates “specialty” treatment so as to prevent or minimize environmental problems. [8]

The conventional method for the treatment of dairy effluent involves a physical treatment followed by aerobic biological treatment in the form of high rate trickling filters or activated sludge process. Often times the post-treatment of dairy wastewater is also done using the physico-chemical treatment methods consisting of coagulation/flocculation by various inorganic and organic natural coagulants, and membrane processes like nanofiltration (NF) and/or reverse osmosis (RO). The organic pollutants like fats and nutrients contained in the dairy waste could easily be removed in aerobic reactors. But a high energy requirement by aerobic treatment methods is the primary drawback of these processes along with large sludge disposal requirements and high operational cost. In order to reduce energy consumption in aerobic treatment, physico-chemical treatment processes may be combined with aerobic treatment as the primary purification of dairy wastewater. Anaerobic treatment processes are most widely used for treating dairy wastewaters. An anaerobic-aerobic combination treatment gives better results but more studies are required to optimize the treatment efficiency. [11]

Membrane methods are promising for producing high quality effluent suitable for direct reuse. The development and application of a membrane bioreactor (MBR) for full-scale wastewater treatment is the most important recent technological advance in terms of biological wastewater treatment. MBR represents an efficient and cost effective process that copes excellently with the growing needs for transforming wastewater into clean water that can be returned to the hydrological cycle without detrimental effects. The energy consumption of aerobic MBR is much higher than conventional activated sludge process due to use air bubbling to prevent the membrane from biofouling. Anaerobic membrane bioreactors have potential for energy-efficient treatment of wastewaters but also membrane fouling being a major hurdle to application.

The Anaerobic fluidized membrane bioreactors (AFMBR) is modified with granular activated carbon (GAC) fluidization in an anaerobic membrane bioreactor (AMBR) which significantly reduces membrane fouling with low energy expenditure, providing a highly effective effluent polishing system. Among the anaerobic processes, fluidized bed reactor has good mass transfer efficiency due to growth of thin biofilm on media particles and well contact between biofilm biomass and bulk. [9]

II. TREATMENT OF DAIRY WASTEWATER

Wastewater from dairies contain mainly organic and biodegradable materials that can disrupt aquatic and terrestrial ecosystems. The dairy industry is one of the most polluting of industries, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well. It generates about 0.2–10 liters of effluent per liter of processed milk with an average generation of about 2.5 liters of wastewater per liter of the milk processed. If discharged without proper treatment of these wastes to the nearby stream or land, will severely cause pollution problems and disrupts complete ecosystem. . [12]

Dairy effluents decompose rapidly and deplete the dissolved oxygen level of the receiving streams immediately resulting in anaerobic conditions and release of strong foul odors due to nuisance conditions. The receiving water becomes breeding place for flies and mosquitoes carrying dangerous diseases. It is also reported that higher concentration of dairy wastes are toxic to certain varieties of fishes and also promote eutrophication. In land received waste water affect the soil quality and soil structure and part of waste water can also leach is to underlying groundwater and affect its quality. This in turn demands the need for appropriate treatment for the dairy wastewater to reduce several environmental impacts.

Common techniques for treating dairy industry wastewaters include grease traps, oil water separators for separation of floatable solids, equalization of flow, and clarifiers to remove SS. Biological treatment consists of the aerobic and anaerobic process. Sometimes anaerobic treatment followed by aerobic treatment is employed for the reduction of soluble organic matter (BOD) and biological nutrient removal (BNR) is employed for the reduction of nitrogen and phosphorus. Sometimes chlorination of the effluent is also done for the purpose of disinfection before reusing the water. [2]

Physico-chemical treatment processes like coagulation/ flocculation, adsorption, and membrane process are required to remove suspended, colloidal, and dissolved constituents. Coagulation and flocculation is a frequently applied process in the primary purification of industrial wastewater (in some cases as secondary and tertiary treatment). Coagulation using chemical coagulants consists of combining insoluble particles and/or dissolved organic matter present in dairy wastewater into large aggregates, thereby facilitating their removal in subsequent sedimentation, floatation, and filtration stages.

Among the various physico-chemical treatment methods, adsorption has been found to be attractive for the removal of organic compounds in wastewaters. Activated carbon (AC) is generally used as an adsorbent for the treatment of various types of wastewaters. Moreover, studies on the mechanism of adsorption is lacking; kinetic, isotherm, and thermodynamics aspects which are important for the design of any adsorption unit. Disposal aspects of the spent adsorbents were also not reported in these studies.

The membrane-treatment process includes microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO), dialysis, and electrodialysis. These methods are very promising where product recovery is feasible and produce high quality effluent suitable for direct reuse. NF membrane treatment is a viable alternative to the conventional treatment by RO because it can operate at lower pressures, lower-energy consumption, and higher permeate recoveries than RO.

Hybrid membrane systems with a combination of RO, NF, and UF are likely to become areas of future research. A combination of membranes with biological and/or chemical methods is likely to achieve the target of zero water discharge in dairy industries.

Owing to the presence of high organic matter, dairy wastewaters are well suited for biological treatment, especially anaerobic treatment. Aerobic biological treatment involves microbial degradation and oxidation of waste in the presence of oxygen. Conventional treatment of dairy wastewater by aerobic processes includes processes such as activated sludge, trickling filters, aerated lagoons, or a combination of these. All compounds of dairy wastewater are biodegradable except protein and fats which are not easily degraded. . [10]

III. ANAEROBIC FLUIDISED MEMBRANE BIOREACTOR (AFMBR)

Despite of various advantages of the aerobic biological treatment of dairy wastewater, there are a number of drawbacks associated with these methods. High energy requirement by aerobic treatment methods is the primary drawback of these processes. Dairy effluents have high COD and organic content and are warm, enabling them to be ideal for anaerobic treatment. Furthermore, no requirement for aeration, low amount of excess sludge production, and low area demand are additional advantages of anaerobic treatment processes in comparison to aerobic processes. [7]

The membrane bioreactor (MBR) appears to be a promising process for the treatment of dairy industry wastewaters. The main advantage of MBRs is the membrane's capacity for completely retaining the biomass, with the effect that the quality of the treated effluent does not depend on the sludge settling characteristics. In addition, MBRs can operate with a higher concentration of mixed liquor suspended solids and a higher solids retention time than conventional systems such as activated sludge. The advantages of these conditions are less sludge production, which causes a reduction in sludge treatment and disposal costs, and a reduction of the reactor volume.

Anaerobic membrane bioreactors (AnMBR) have demonstrated the capability to achieve a high quality effluent at hydraulic retention times (HRT) comparable to that of aerobic processes. Membranes prevent organism loss from the reactor, thus allowing the required long solid retention times (SRT) needed for anaerobic processes, and yield a good permeate quality through filtration. An important issue remaining with AnMBRs is membrane fouling control.

Anaerobic fluidized membrane bioreactor comprises of a bioreactor including biochemically active organisms; fluidized particles which is a support media to be attached by the organisms; and membranes which permit treated water to pass through. The membranes are installed internally or externally to the bioreactor. The particles may be granular activated carbon or other suitable materials. The fluidized particles serve not only as support media for microorganisms, but also as media for sorption or otherwise retention of matter that can cause membrane fouling and as an abrasive material for cleaning the membrane surface. The membranes may be of different types such as hollow fiber membranes, tubular membranes, or flat sheet membranes. The fluidized particles may be sand, or granular activated carbon, or other materials as commonly used in traditional fluidized bed reactors. [6]

The fluidized membrane bioreactor of this invention is particularly applicable with anaerobic treatment in helping to achieve good wastewater treatment efficiency. The invention relates to fluidized membrane bioreactors which combine a fluidized-bed biofilm reactor with membrane filtration so that the bioreactor can achieve a high efficiency of wastewater treatment together with ease in maintenance. The advantages of combining a fluidized bed reactor with membrane filtration are not only that biomass retention is improved, but also the clogging of membranes through which treated effluent passes is significantly reduced through the combined sorption and scouring action of the fluidized particles in the reactor, which are in direct contact with the membranes. Therefore, this action of a fluidized bed system helps to reduce the major problem with membrane bioreactors in an energy efficient manner. Therefore, additional gas injection for vigorous agitation demanding much energy is no longer required.

Anaerobic processes, however, operate without air or oxygen introduction, and instead produce useful energy in the form of biogas. A specific need of anaerobic treatment is a long solids retention time (SRT) to prevent washout from the reactor of slow-growing methane-forming anaerobic bacteria. Membrane bioreactors can be advantageous for anaerobic treatment of dilute wastewaters such as domestic sewage in that the membranes prevent washout of anaerobic bacteria and thus can provide the long SRT needed, while operating at short hydraulic detention times as required to reduce reactor size and cost. . [13]

IV. APPLICATIONS IN WASTEWATER TREATMENT

Jai et al.,have discussed recent advancements in the treatment of dairy wastewater and the areas where further research is needed have been identified. Anaerobic treatment processes are most widely used for treating dairy wastewaters but these processes partly degrade wastewater containing fats and nutrients as dairy wastewater. So, subsequent treatment is necessary for anaerobically-treated dairy wastewater. The fats and nutrients could easily be removed in aerobic reactors. But a high-energy requirement by aerobic treatment methods is the primary drawback of these processes. Membrane methods are promising for producing high quality effluent suitable for direct reuse. [1]

Jaebo et al.,conducted a study to evaluate the feasibility of the single anaerobic fluidized membrane bioreactor (AFMBR) system. Performance of a AFMBR was compared with that of a staged anaerobic fluidized membrane bioreactor system (SAF-MBR) that consisted of an anaerobic fluidized bed bioreactor (AFBR) followed by an AFMBR. COD removal efficiencies and changes in TMP of each system were compared. Also, resulting concentrations of suspended solids, EPS and SMP within the bulk liquid of each reactor were compared. [5]

Gao et al.,studied the feasibility of integrated anaerobic fluidized-bed membrane bioreactor (IAFMBR) for domestic wastewater treatment with methane recovery. An IAFMBR system with granular activated carbon (GAC) as carrier was developed to treat domestic wastewater with energy recovery. Various HRTs were tested for the performance of a laboratory IAFMBR including COD removal and biogas production in relation to membrane fouling. The amount of GAC added into the inner tube of IAFMBR controlled essentially the membrane fouling process. [4]

Kim et al.,evaluated the advantages of the AFBR when combined with that of an internal submerged membrane bioreactor, termed the anaerobic fluidized membrane bioreactor (AFMBR).The AFMBR used as post-treatment for effluent polishing was evaluated for its energy requirements as well as its ability to help meet stringent COD and SS effluent requirements. Here, granular activated carbon (GAC) was used as the fluidized medium to support biological growth.Thus, addition of an AFMBR to an existing anaerobic treatment system for post-treatment might result in the rapid development of a good polishing system. Also, the AFMBR by itself may be sufficient as a stand-alone treatment system, something not yet attempted. An additional benefit of a fluidized bed reactor with GAC is the potential to remove refractory trace contaminants of concern through sorption, as well as biodegradation of the readily biodegradable organic materials. [3]

V. CONCLUSION

Anaerobic treatment rules over aerobic treatment processes due the various advantages like less energy requirement as there is no aeration required and less sludge disposal concerns. Membrane technology has developed as a capable as well as effective method for treating various domestic and industrial effluents. Hence the combination of anaerobic process with membrane technology is expected to treat effluents with high efficiency, even without a requirement of pretreatment and may results in a high quality effluent which can be directly discharged. AFMBR system is one such combination which is modified with GAC fluidization to reduce the membrane fouling. Industrial wastewater treatment using AFMBR is seldom conducted and so far literature indicates that the domestic and municipal effluents treated using this methods results in 90-96 % COD removal efficiency. More investigations are to be piloted to study the application of AFMBR for industrial wastewater treatment.

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