International Journal of Research in Engineering, Science and Management
Volume-2, Issue-12, December-2019
www.ijresm.com | ISSN (Online): 2581-5792

A Review Study of Anaerobic Membrane Bioreactor for Wastewater Treatment

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***Abstract*: The aim of the study is to evaluate the potential of anaerobic membrane bioreactor technology for wastewater treatment. This bioreactor has increasingly researched as a cost effective alternative with a high degree of pathogen removal. It focusses mainly on different types of anaerobic reactors that membrane is coupled to. And to detect how fouling problems are overcome since its being a major hurdle to application. It was found if membrane is placed directly in contact with activated carbon the fouling can be controlled. The performance of the bioreactors at various factors were studied for both biological and filtration of anaerobic bioreactor including strength and limitations.**

***Keywords*: AMBR-Anaerobic Membrane Bioreactor, wastewater, fouling, anaerobic, COD, BOD, SS, UAPB.**

1. Introduction

Anaerobic treatments which are commonly applied to wastewater treatment have the following main benefits compared to aerobic treatments: minimum sludge production due to the low biomass yield of anaerobic organisms, low energy demand since no aeration is required, and biogas production.

Municipal wastewater is the most abundant type of wastewater that falls into the category of low strength waste streams. The anaerobic methods helps to increase the demand by converting chemically bound organic pollutants to energy sources. Therefore, selection of a most appropriate method is important to enhance the technology. The simple anaerobic treatment is not sufficient to meet requirements of the ideal drinking water. So anaerobic membrane bioreactor which are capable of achieving high level of effluent quality and alternatively it requires less energy because no aeration is required for mineralizing the organics. In this treatment it produces nutrients in the form of ammonia and phosphates.

This application has now increasingly been applied during the last decade. The retention of slow growing anaerobic biomass was the most bigger challenge. It is important to highlight the importance of AMBR because in aerobic process high amount of aeration is required to remove organic materials. Even though the use of AMBR is not applied on large scale, it is emerging as interesting topic for scientists and researchers. By applying this anaerobic methods superior effluent quality can be achieved in terms of COD, SS and pathogens. But despite this many uses it has various drawbacks such as low flux, membrane fouling, high capital and operational costs that limits the extensive use of AMBR.

Recently several new researches have been published. Our review paper mainly focuses on the perspectives of various types of membrane bioreactors, fouling characteristics, various uses and limitations.

2. Types of Anaerobic membrane reactors

A. Continuous Stirred Tank Reactor (CSTR)

CSTR is the most common anaerobic process. In general, CSTR are operated at equal HRT and SRT without any internal biomass retention device. In reactor biomass concentration can be increased by applying a secondary clarifier with return flow, giving in an anaerobic membrane separation device. In membrane coupled with CSTR, the complete retention of solids decouples SRT from HRT, which leads to an increase in biomass.

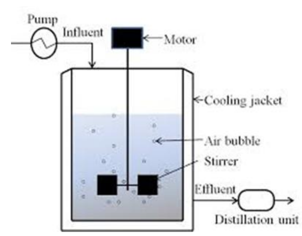

Fig. 1. Continuous stirred tank bioreactor

B. High rate anaerobic reactors

In high rate anaerobic reactors, biomass is retained by the formation of sludge material. Effluent concentration is less than the concentration of the biomass, which makes it ideal for high rate. With the membrane filtration we can get very low SS concentrations.

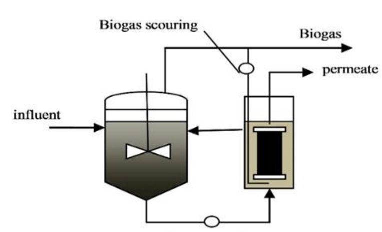

Fig. 2. High rate membrane bioreactor

C. Submerged anaerobic membrane bioreactor

The submerged anaerobic membrane bioreactor consists of an anaerobic reactor. Each membrane tank features one ultrafiltration of the sludge and organic compounds giving a high concentration of pure water.

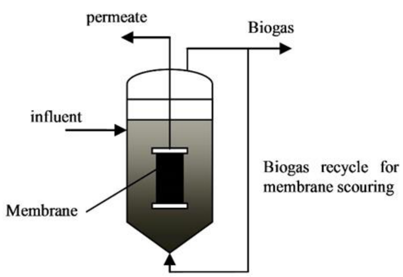

Fig. 3. Submerged anaerobic membrane bioreactor

D. The external crossflow membrane filtration

In this membrane modules are placed in a pressurized circulation loop located outside the bioreactor. Membrane fouling is prevented in the crossflow by the use of shear forces created by the operation.it can purify a high level of concentrated wastewater, which is not easily biodegradable. The flow is considerably low due cross current effects.

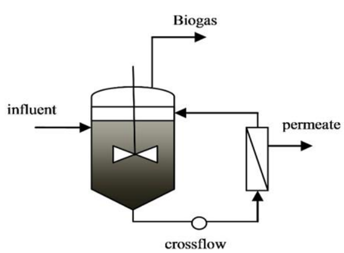

Fig. 4. Crossflow bioreactor

E. Other reactors

There are several membrane bioreactors which are used for various other purposes. The main criteria or need is to get the process done economically with low cost of construction and working.

3. Membrane fouling

The membrane fouling is the major problem with the membrane bioreactor. Fouling is the increase in the membrane resistance, by deposition of some materials on the pores of the membranes. Many researches has been carried out on membrane separation. Fouling can be classified as three types:

- Inorganic fouling which refers to the deposit of inorganic material like salts, clay and metal oxides.
- Organic fouling which refers to all kind of deposit of organic material like grease, oil, surfactants, proteins, and other organic biopolymers.
- Biofouling which shows the formation of biofilms by compounds and microorganisms attached and growing at the membrane surface.

The fouling can be prevented by various ways;

- Applying proper pretreatment to the feed water,
- Employing appropriate physical or chemical cleaning protocols,
- Reducing the flux,
- Increasing the aeration,
- Chemically or biochemically modifying the mixed liquor,
- Membrane surface modification.

The use of activated carbon in the direct contact with the membrane surface has been proved very effective because it makes the pores open again by adsorbing the materials on it. Which enhance the performance of membrane bioreactor.

4. Applications of AMBRs in wastewater treatment

AMBRs have been tested effectively for the treatment of a wide range of wastewaters and high solid content wastes, which includes food industries, paper industry, municipal wastewater. In general, it has been showed that AMBR can achieve around 90-95% of COD removal and methane production of 0.25 to 0.35 m^3 CH4/kg COD.

Recently there is an increasing interest in this applications to wastewater treatment. It can work at a temperature range of 20˚C-30˚C foe upto 24 to 6 hours. Studying about the cost structure it will be feasible because doing the wastewater treatment it produces methane, ammonia and various other materials which helps in the reducing the cost structure and make it more economical.

It could considerably be not economical in the areas with very low temperatures as it requires some amount of heat to complete the process. and if it is done in this situation there will be a large requirement of energy to bring the required temperature.

5. Membrane filtration performance in AMBR

The performance of the membrane bioreactors is determined on the basis of the parameters of the operation of the equipment's. The key design of the membrane filtration is the operation flux, which directly affects the capital and operational cost. The process determines the membrane surface area. The observation is made based on the various conditions:

- Flux ranging from 6.7-10 LMH were achievable for the treatment of wastewaters.
- Intermittent permeation is required to achieve long term stable operation.
- The anaerobic reactors can handle more amount of SS than the aerobic processes, where the high MLSS concentration can considerably reduce the oxygen transfer efficiency, resulting in the drastic change in the filterability of the mixed liquor.

The membrane fouling is still the major factor affecting the efficiency of the AMBR. It is mainly caused by graduate accumulation of the colloidal or soluble materials. The main strategy to control membrane fouling is to include crossflow for the membrane filtration. Other techniques include membrane vibration, activated carbon bed, ultrasonic methods etc.

6. Biological parameters affecting membrane performance

The membrane performance was studied on various parameters. Increasing the amount of COD and BOD in the influent resulted in decrease in efficiency. Permeate was significantly affected by organic loading rate.

The increase of hydraulic retention time resulted in increase of BOD removal efficiency. Since due to organic materials ammonia and other gases were present in large amount, which led to high degree of nitrification. If the aeration was lowered it was observed that the gases are not separated completely. Continuous process was promoting the high level of sludge removal and formation of various gases. The turbidity removal efficiency was increased.

7. Limitations of AMBR

AMBR is relatively expensive to install and operate it. It requires high energy and found to reject only 98% of organic carbon and 90% of ammonium nitrogen. The fouling is also a major drawback to this application. High level of greenhouse gases are produced in the process.

This are given as follows:

- Membrane surface fouling
- Membrane channel clogging
- Process complexity
- High capital cost and operating costs
- High running costs
- Limited flow capacity
- Cleaning chemicals necessary
- Increased potential
- Fine screening required
- More complex operations

If the particle size is less than that of pores, the particles will enter the membrane, gradually reducing the size of the pores until they completely block.

8. Conclusion

The various types of AMBRs were studied. The continuous and crossflow operations were found more feasible. This bioreactor has a wide range of applications in wastewater treatment. The membrane fouling which is a major drawback was studied and to overcome this issue. The various applications were studied. The performance of AMBR at filtration and biological parameters were brought into consideration and how it affects the overall efficiency of the reactor.

Acknowledgement

The authors would like to thank our guide Prof. Kiran D. Bhuyar, Department of Chemical Engineering, Priyadarshini Institute of Engineering and Technology, Nagpur. For the support to complete our study.

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