

Treatment of Wastewater of Food Industry by Membrane Bioreactor

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Abstract: Food industry requires a large quantity of water for various processes. Compared to other industrial sectors, food industry requires more water, used in throughout most of the plant operations, such as production, cleaning, sanitizing, cooling and materials transport, among others. The treatment mechanisms of contaminants in wastewater are highly dependent on the design and operational characteristics of the wastewater treatment plants (WWTPS). The membrane biological reactors (MBR) have proven to be efficient for the treatment of industrial wastewaters over conventional wastewater treatment plants when treatment efficiency is an important consideration. The present study aims to analyze effectiveness of membrane bioreactor technology as a modern tool to minimize the water pollution level caused by noodle, curd, and infant food plants. The analysis of pollutants in influent and effluent from food industry was done on the monthly basis. The pollution indicators (BOD, COD, total suspensions, temperature, appearance, and pH) of wastewater of food industry had high values but they remained within the range after treatment in the MBR. When analyzed at monthly intervals, 98% BOD₅ and above 99%, COD removals were achieved. Overall efficiency of removed pollutants as COD, BOD and TSS from the wastewater was more than 90%. MBR technology is thus a better and advanced method to treat wastewater of food industries.

Keywords: Industrial wastewater, Membrane Bioreactor (MBR), Membrane filtration, ultra filtration.

I. INTRODUCTION

Waste water produced by food Industry is a potential hazard to the natural water system (Joshi, 2012). This wastewater contains many inorganic and organic matters, which are toxic to the various life forms of the ecosystem (Spina et al. 2012). The majority of food processing industries are considered by very high water intake and high organic compounds rich wastewater generation. Waste water treatment can involve physical, chemical or biological processes or combinations of these processes depending on the required outflow standards. Food processing industries include dairy/milk products, liquor production, vegetable oil, and brewery. These industries require large amounts of water and also discharge wastewater of varying quality. The quality parameter of waste water produced at food industry is pH, temperature, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS) and appearance and odor. The removal mechanisms of wastes and contaminants in wastewater are highly dependent on the design and operational characteristics of the wastewater treatment plants (WWTPS). The membrane biological reactors (MBR) have proven to be efficient for the treatment of many industrial wastewaters in recent few years when treatment efficiency is an important consideration. The term membrane bioreactor (MBR) defines a combination of a biological process and membrane separation. Membrane Bioreactor (MBR) combines a conventional activated sludge treatment (biological) with a membrane liquid-solid separation process (URASE, 2016). MBRs also present better removal efficiency of micropollutants, persistent organic pollutants and slowly biodegradable pollutants (Bernhard et al., 2006).

The MBR showed a high capacity for removing organic matter and color, which can be justified by the elevated biodegradability of the effluent and the high concentration of biomass (Janczukowicz et al., 2008). The bioreactor and the membrane each have a specific function. Biological degradation of organic pollution is carried out in the bioreactor by adapted microorganisms (Nechitailo and Nagornaya, 2015). Separation of microorganisms from the treated wastewater is performed by the membrane with nominal pore size 0.1 – 0.4 micron. In India, MBR systems are being used for the treatment of waste water from hotel industries, residential area and housing complexes like sewage water. Treated effluent is of much better quality that it is reused in gardening, flushing, cooling and other cleaning purposes (Vigneswaran and Sundaravadivel, 2004). The idea for coupling the activated sludge process and membrane separation was first reported by research conducted at Rensselaer Polytechnic Institute, Troy, New York, and Dorr-Oliver, Inc. Milford, Connecticut, US (Jyoti et al., 2013). The first MBR installation (Membrane Sewage System-MST) commercialized in the 70's and 80's was made by Dorr-Oliver, Inc., with flat sheet ultrafiltration plate and frame membrane. Since 1990, MBR technology has been taken up in North America and Europe and is now experiencing rapid growth in a wide variety of applications. The main objective of this study is to analyse effectiveness of membrane bioreactor technology as water pollution control equipment's adopted by the food industry to minimise the water pollution level, the

treatment process of membrane bioreactor help in removal of materials that carried over from a secondary treatment settler and the efficiency of membrane bioreactor in wastewater treatment over conventional activated sludge treatment plants.

II. MATERIALS AND METHODS

The industry selected for study was food processing and production industry. Water is used in industry for many purposes like cleaning, washing, production and drinking. The wastewater generated was treated by membrane bioreactor before disposal. Membrane bioreactor (MBR) configuration exists in two forms: internal submerged and external sub-stream. The study is based on internal submerged-type membrane bioreactor.

A. Membrane Bioreactor

There are many companies which have installed membrane bioreactor for wastewater treatment. The present project site has installed an GE Fanuc Programmable Logic Controller (PLC) and Panel View 600 HMI with a Human Machine Interface (HMI), installed in the main NEMA 12 control panel, monitors and manages all critical process operations. In an MBR system, the membranes are submerged in an aerated biological reactor. The membranes have porosities ranging from 0.035 microns to 0.4 microns which are considered between micro and ultrafiltration. This membrane system removes the conventional sedimentation process wastewater treatment and the biological processes can operate at higher concentration of contaminants.

Non-biodegradable compounds tend to be discharged with the sludge rather than with the treated water. MBRs remove dissolved organics that cause biological oxygen demand (BOD) and suspended materials in wastewater. MBRs replace sedimentation and tertiary filtration in conventional wastewater treatment systems by providing an absolute barrier for the removal of suspended solids. The efficiencies of the MBR operating at HRTs of 6 and 8 hours were similar, so the hydraulic retention times (HRT) of 6 hours was chosen as the optimum. Equalization is required for any system with variable flow rates. An equalization (EQ) tank is normally installed upstream of the biological tank. The required equalization volume can also be incorporated into the biological tank under certain circumstances. Equalization Transfer Pumps transport wastewater from the equalization tank or lift station to the process tank. Equalization Aeration System is used to mix air for the equalization tank and ensure proper mixing and prevents settlement of solids.

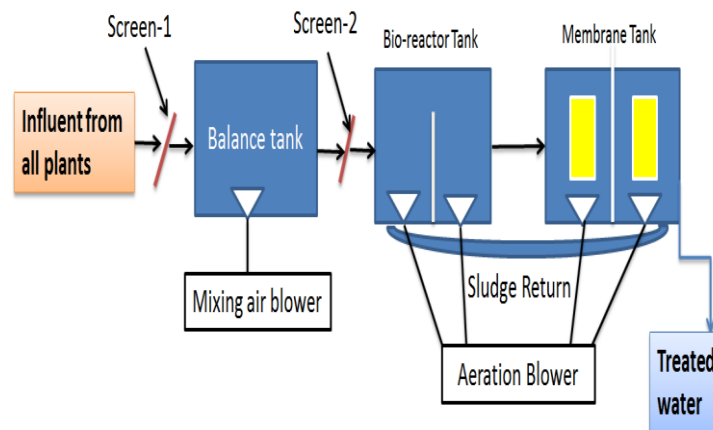


Figure.1: Membrane Bioreactor and its treatment process

The wastewater collected from all the three plant i.e. Noodle, curd and Infant food plants into the balance tank of the WWTP (Membrane bioreactor) through the screen. Screening System removes trash and non-biodegradable solids, such as hair, lint, grit and plastics may foul or damage the membranes if allowed to pass into the membrane chamber. An internally-fed screen with mesh or punched-hole openings less than or equal to 2 mm in diameter with no possibility of bypass is required for optimal MBR operation.

Screened wastewater will flow to a bioreactor tank where MLSS (mixed- liquor suspended solids) is maintained by ensuring proper aeration to maintain required MLSS to degrade the BOD and other biodegradable contents of waste water. The process aeration blowers provide air for the biological tank and ensure that sufficient oxygen is available to maintain the biological processes in the tank. Sludge wasting is accomplished by periodically diverting mixed liquor from the recirculation return line, via manual control or by pulling directly from the bioreactor. The frequency of wasting is a function of influent characteristics, reactor design and operator preference.

B. Physiochemical Parameters

Different parameters of influent from all the three plants and effluent from treatment plant analysed with different methods like pH observed with the help of pH meter, BOD₅ with HACH BOD meter, COD with HACK COD reactor, TDS by filtration of a test portion, evaporation to dryness of filtrate and weighing of residues, TSS by filtration of a sample through filter, drying and weighing. Percentage efficiency of MBR influent and effluent was calculated by the following formula:

$$\% \text{ Efficiency of MBR} = \frac{\text{Average of influent} - \text{Effluent}}{\text{Average of influent}} \times 100$$

Table-1: The physico-chemical parameters of membrane bioreactor plant

Name of parameter	Influent				Effluent from MBR	Indian wastewater Standard (CPCB, 2006)	% efficiency of MBR
	Noodle plant	Curd plant	Infant food plant	Average			
pH	7.27	10.72	7.5	8.49	6.67	5.5 -9.0	-
BOD ₅ (mg/l)	540	744	660	648	30	100	97.31
COD (mg/l)	1240	1120	1650	1336.7	20	250	98.79
TDS(mg/l)	810	900	820	843.3	22	2100	97.29
TSS (mg/l)	240	220	370	276.7	12	100	96.84
Temperature (°C)	31.7	34.3	35.7	33.9	32.1	40	-
Appearance	Clear with settled matter at bottom	Milky	Grey	-	colourless	Normal	-
Odour	Slightly offensive	Pungent	Pungent	-	odourless	-	-

III. RESULTS AND DISCUSSION

MBR (Membrane bioreactor) technology is a modern wastewater treatment technology, having the several benefits over conventional activated sludge processes (Judd, 2010). The physiochemical characterization of influent from all the three plants and effluent from membrane tank is given in the Table.1. The key indicators of pollution in wastewater from food industry are BOD, COD, pH and TDS & TSS. Assessment and characterization of wastewater are important to evaluate the quality of wastewater. In India, the Central Pollution Control Board (CPCB) provides standards with their limiting concentrations for the discharge of environmental pollutants from the food industry. The pH directly affects the performance of a secondary treatment process because the existence of most biological life is dependent upon a narrow and critical range of pH (Metcalf and Eddy, 1991 & 2003). The dissolved solids content of the wastewater is of concern as it affects the reuse of wastewater for agricultural purposes. The pH was controlled and balanced by the plant by degrading certain compounds into simpler forms. The effluent discharge from the plant had pH within the permissible limit given by Central Pollution Control Board (2006) (Table.1).

The attachment of biomass or entrapment of solids to a reticulated polyurethane foam media, which had been used as a packing medium in an anaerobic filter, increased the colloidal particles removal efficiency (Elmitwalli et al., 2000). The total suspended solid concentration was high from infant food plant but after treatment in MBR plant, the percentage reduction in TSS was 95% - 97% satisfactory. Efficiency of the aeration tank was calculated by considering percentage reduction of BOD. The BOD₅ in influent from the curd plants was highest than other two plants i.e. 744 mg/l which was very much higher than the permissible limit of discharge into environment given by Central Pollution Control Board (2006) (Table.1). The percentage reduction in BOD was 95% - 98% satisfactory. Similarly, the COD was highest of wastewater from infant food plant i.e. 1650 mg/l. The percentage reduction in COD was 98% - 99% by the plant. As a consequence, the efficiency of COD removal was higher than that of BOD₅ removal. The percentage reduction in TDS was 95% - 98%. Figure 2. shows the comparison between different parameters of effluent and the Indian Wastewater Standards. Graph shows that the effluent has much less value than the standard given by CPCB for discharge of wastewater into environment. The high-quality effluent produced by a MBR can either be used directly for water reuse applications after disinfection or be fed directly into a reverse osmosis process without further pre-treatment. The overall efficiency of MBR was very satisfactory and impressive which proved it a better way for treatment of highly polluted wastewater from the food industry. The treated water from the MBR plant can be reused and reduce the presence on fresh water/ ground water. Treated effluent was of much better quality hence it can be reused in gardening, flushing, cooling and other cleaning purposes.

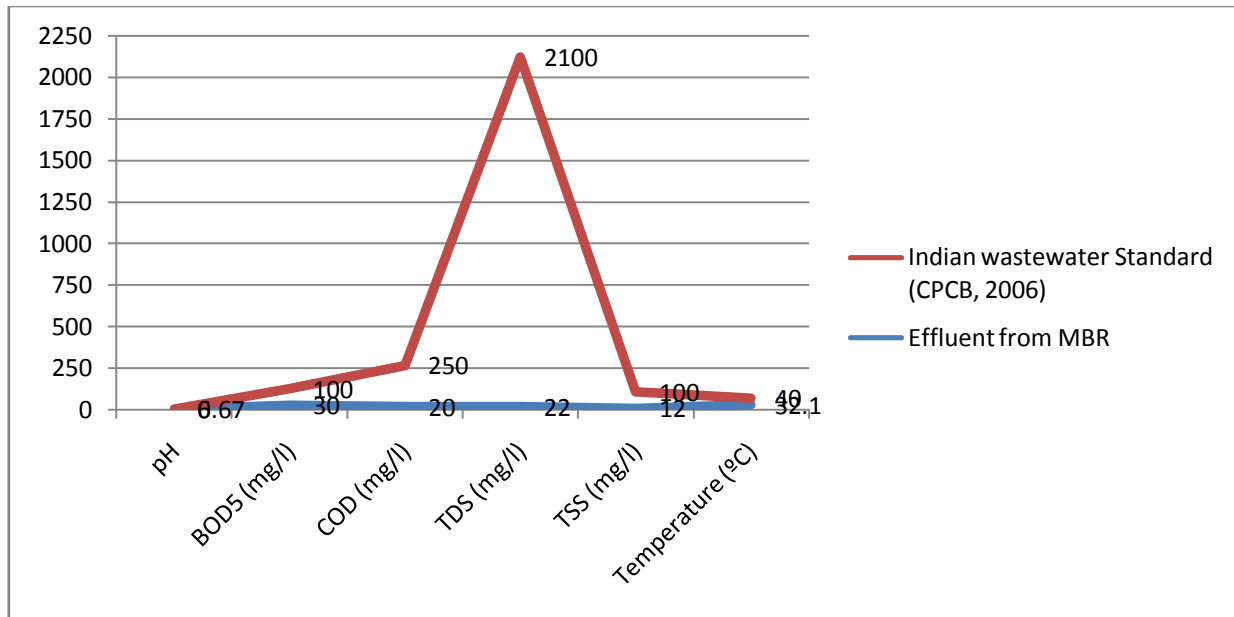


Fig.2: Comparison of different parameters with Indian wastewater standard.

IV. CONCLUSION

The MBR concept is similar to conventional biological wastewater treatment except for the separation of the activated sludge and treated wastewater that is done by membrane filtration. The treatment in the MBR system provides a high degree of treatment in terms of suspended solids and organic matter removal. The permeate of the MBR showed excellent quality with low concentrations of organic matter and nutrients. In general, it can be concluded that MBR technology proved to be a very efficient tool for water treatment and water reuse due to its advantages such as high water quality, small footprint, modularity, and robustness. The overall efficiency was in the order COD < TDS < BOD < TSS. MBR technology is well-suited for the treatment and reuse of particular effluents with high biological degradability such as food industry and also be used for water reuse in commercial laundries, beverage, and cosmetics industries.

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