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ANALYSIS OF SUGAR INDUSTRY WATER BY USING A COMBINATION OF MBR AND NF PROCESS

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Abstract

The major aim of industrial wastewater treatment is to remove as much of the suspended solids and impurities as possible before the remaining water is discharged back to environment. Our objective is to reuse the treated water for domestic purpose by using advanced method for waste water treatment i. e. NF to MBR in combination. Nanofiltration (NF) is a pressure driven membrane process.NF membrane is termed as "Loose" reverse osmosis membrane. Cut-off characteristics of membrane play important role to remove smaller molecular weight substances. The membrane bioreactor (MBR) concept is a combination of conventional biological wastewater treatment plant and membrane filtration. The concept is technically similar to that of a traditional wastewater treatment plant, except for the separation of activated sludge and treated wastewater. Our present study emphasizes the industrial waste water treatment (sugar waste and dairy waste) by using a combination of advanced methods of Nanofiltration and Membrane bioreactor. The parameters (i.e., BOD, COD, TDS, pH) of treated water were analysed and compared with that of MPCB & CPCB.

Index Terms: *Nanofiltration, Membrane Bioreactor.*

1. INTRODUCTION

1.1Nanofiltration (NF)

NF membranes were first recognized in the late 1980's and are defined as loose reverse osmosis membranes, because they have a relatively low sodium chloride rejection(20−80%), but much greater water permeability. The MWCO of theses membranes is200−1000 g/mol. NF membranes are used when low molecular weight solutes (e.g., salt, glucose, lactose, or micro pollutants) must be rejected at an operating pressure of 10−25bar. Most NF membranes are composite membranes consisting of a thin, dense layer of<2 nm pore size coated or interracially polymerized on an open support. NF applications include desalination of brackish water, removal of micro pollutants, water softening, wastewater treatment, and retention of dyes in the textile industry. Over the past 8 years, the significant growth of papers published on NF membranes in many different areas highlights the importance of this process .Nanofiltration (NF) is a pressure driven membrane process. Hydraulic pressure is used to overcome the feed solution's osmotic pressure and to induce diffusion of pure water (referred to as permeate) through a semi-permeable NF membrane. The residual feed stream (referred to as retentate, concentrate, or reject) is concentrated by the process, and depending on water quality, may be suitable for further water recovery in additional downstream unit processes; otherwise, the residual stream requires disposal. NF is designed to achieve high removal of divalent and multivalent ions (e.g., calcium, magnesium, sulfate, iron, arsenic, etc.), and is occasionally referred to as membrane softening. NF may achieve moderate to low removal of monovalent ions (e.g., sodium, potassium, chloride). NF is commonly employed to remove hardness from brackish groundwater to produce potable water. Water characterized by high concentrations of calcium or magnesium and monovalent salts may be treated with NF prior to a reverse osmosis. An illustration of the process is shown below.[3]

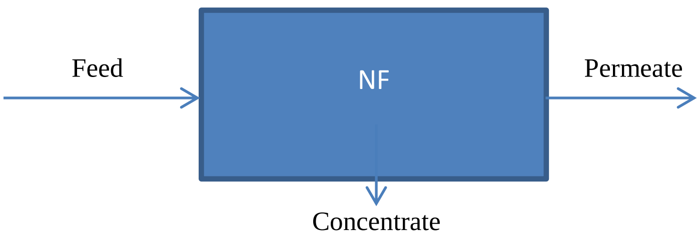

Fig- 1: Illustration of Nanofiltration

Heavy metals are one of the major contaminants in industrial effluents from pesticide, smelting, dye manufacturing electronic industries, etc. Due to their non-biodegradable nature, heavy metals can accumulate in the body and may lead to disastrous side effects, such as nausea, bone lesions, renal disturbances cancer, or even death. As a result, the removal of heavy metals from effluent streams before discharge is of utmost importance to the society.

1.1.1 Separation Mechanism in NF

Since NF membrane exhibits properties between those of ultra filtration (UF) and reverse osmosis (RO), both charge and size of particle play important role in NF rejection mechanism. Simpson et al. (1987) has described NF as a charged UF system whereas Rohe et al. (1990) has referred it as low pressure RO system. However, NF has advantages of lower operating pressure compared to RO, and higher organic rejection compared to UF. For the colloids and large molecules, physical sieving would be the dominant rejection mechanism whereas for the ions and lower molecular weight substances, solution diffusion mechanism and charge effect of membrane play the major role in separation process. Macon (1998) presented the NF rejection mechanisms into following four steps.

Wetted surface – water associates with the membrane through hydrogen bonding and the molecules which form the hydrogen bonding with the membrane can be transported.

Preferential sorption/Capillary rejection – membrane is heterogeneous and micro porous and electrostatic repulsion occurs due to different electrostatic constants of solution and membrane.

Solution diffusion – membrane is homogeneous andnon-porous, and solute and solvent dissolve in the active layer of the membrane and the transport of the solvent occurs due to the diffusion through the layer.

Charged capillary – electric double layer in the pores determines rejection. Ions of same charge as that of membrane are attracted and counter-ions are rejected due to the streaming potential.

1.1.2 Characterization of Nanofiltration Membranes

Most porous nanofiltration membranes, either polymeric or inorganic, have a complex porous structure, with a set of pores with various sizes ranging from a few nanometers to several tens of nanometers which determines mass transport through membrane. There are several well established techniques for the determination of pore size and pore size distribution. They include the bubble point technique, mercury porosimetry, the microscopic approach, solute transport method, perm-porometryandthermo-porometry. AFM (atomic force microscope) can image the non-conducting sample without damaging the membrane. While SEM (scanning electron microscope) requires heavy metal coating for non-conducting sample and high beam energy which may damage polymeric membranes. However, average pore sizes obtained from SEM were smaller thanthoseobtained by AFM due to the sample preparation. In addition, AFM images are distorted by convolution between pore shape and cantilever tip shape. Moreover, from SEM and AFM, the images can only give structure information on the membrane outer layer surface without pore inside morphology.

1.1.3 Applications of Nanofiltration

Dairy Industry

Food and Beverage Industry

Textile and Dyes

Industrial Process and Waste Water

Biotech\Pharmaceuticals

1.2 Membrane Bio-Reactor (MBR)

The membrane bioreactor (MBR) concept is a combination of conventional biological wastewater treatment plant and membrane filtration. The concept is technically similar to that of a traditional wastewater treatment plant, except for the separation of activated sludge and treated wastewater. In an MBR installation, this separation is not done by sedimentation in a secondary clarification tank, but by membrane filtration. MBRs are used to treat biologically active wastewater feeds from municipal or industrial sources. The MBR process competes with biological treatment such as the Conventional Activated Sludge (CAS) process used in municipal wastewater treatment applications. In addition to CAS, industrial wastewaters can be treated with Rotating Biological Contactors (RBC)and Sequencing Batch Reactors (SBR),depending on application requirements

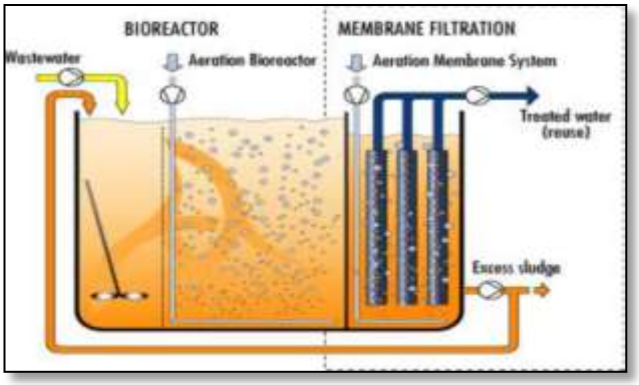

Fig-2: Membrane Bio-Reactor Filtration

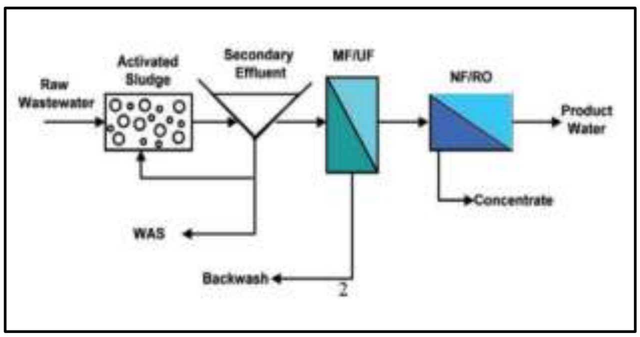

Fig-3 : Stages in MBR Filtration

1.2.1 Types of Membrane Bioreactor Configurations

Membrane separation is carried out either by pressure-driven filtration in side-stream MBRs (Fig.3.1.a.) or with vacuum-driven membranes immersed directly into the bioreactor, which operates in dead-end mode (Fig. 3.1.b.) in submerged MBRs. The more common MBR configuration for wastewater treatment is the latter one, with immersed membranes, although a side-stream configuration is also possible, with wastewater pumped through the membrane module and then returned to the bioreactor. The energy consumption required for filtration in submerged MBR is significantly lower. Both configurations need a shear over the membrane surface to prevent membrane fouling with the constituents of mixed liquor.

1.2.2Membrane surface fouling

Three different ways of defining fouling:
Practically: reversible, irreversible or irrecoverable
Mechanistically: surface coating, pore plugging
Material type: chemical nature, particle size, origin

Membrane performance can be negatively affected by a number of species whose concentration and/or presence in the feed water must be controlled. These species are divided in two categories: substances capable of damaging the membranes and species with potential for membrane fouling or scaling. The discussion is concentrated on fouling, which is the major problem faced in any membrane separation. Membrane fouling, if not controlled, is detrimental to the overall process efficiency because of the increased energy requirements, reduced plant productivity and increased cost of chemicals due to cleaning as well as the shorter lifetime of the membranes, which also lead to an increase of the total production cost. Moreover, membrane fouling may alter the surface characteristics of NF/RO membranes, which in turn could potentially influence the removal of undesirable dissolved species, including pesticides.

1.2.2 Membrane foulants and their characteristics

A rigorous characterization of membranes could provide necessary information on the nature of foul ants and their associated fouling mechanisms. For example, an FTIR spectroscopy of membranes at different incident angles demonstrated that internal pore adsorption is mainly responsible for fouling in ultra filtration membranes , consistent with the results of preferential NOM adsorption onto internal pore surfaces obtained by Junker and Clark. The streaming potential, contact angle, and XPS measurements were used by Junker and Clark to investigate the mechanisms for adsorptive fouling by humic substances under the influence of calcium ions and different pH conditions. He used the FTIR, X-ray diffraction, X-ray fluorescence, and SEM techniques to study precipitation scaling attributed to inorganic such as calcium carbonate and calcium sulfate. These researchers further observed that heterogeneous crystallization of inorganic and organic deposits caused more significant flux decline than homogeneous crystallization of inorganic deposits alone, consistent with the earlier findings of Schafer.

1.2.3 Future of MBR

Market trends indicate MBR technologies will be increasingly utilized as part of wastewater treatment, water reuse programs to conserve our natural water resources and to provide new water sources. There are roughly 600 operating plants in the U.S. and 6,000 worldwide. From small, point-of-use plants to large 40 MGD municipal plants, MBR systems are now considered mainstream and widely accepted as best available treatment. Building on numerous system innovations, the technology is considered by many industry professionals to be “the treatment technology of choice” regardless of the size or application. This type of support, coupled with industry improvements in the technology, will take MBR to the next level to become “not just an alternative” but “the treatment of choice” in the next few decades.

1.1.1. Applications of MBR

Today MBR systems are most widely used in treatment of wastewater (industrial and municipal) in many countries of the world like USA, England, Germany, Norway, Denmark, Netherland, Kuwait, UEA and specially countries from Fareast of Asia such as Japan, South Korea and china.

MBRs are used for the treatment of chemical wastewater, oily wastewater, Landfill Leach ate, Color Industry, Leather Industry, Dying Industry, Paper Industry, Dairy Industry, Hospitals and Lab waste water Liquid, hazardous waste water, Waste Oil Processing, Chemical-pharmaceutical waste water, Tank cleaning waste water, Groundwater redevelopment, Automobile Industry, Laundry waste water, municipal wastewater and gray water .

3. CONCLUSION

After studying all different wastewater treatment methods , it is still not easy to choose only one method globally , because each country have different preference for choosing of treatment methods according to their region , geographical , political and financial conditions or even between plants or individual systems .In this project, we treated waste water by using MBR TO NF in combination.

From Result & calculation we observed that there is 80%(i.e 96mg/l) decrease in COD value of sugar waste and 81.8% (i.e 120mg/l) decrease in COD value of dairy waste .Also we observed 88.7%(5.12mg/l) decrease in BOD value of sugar waste and 86%(7.68mg/l) decrease in BOD value of dairy waste.

By comparing the treated waste water values with MPCB(BOD=100mg/l, COD=250mg/l) and CPCB(BOD=100mg/l,COD=200mg/l) standards ,we can conclude that the treated waste water can be reused for household purpose.

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