An Experimental study on Sewage treatment using Membrane BioReactors

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***Abstract*- Water is becoming an increasingly scarce resource and planners are forced to consider any source of water which might be used economically and effectively to promote further development. The total supply of freshwater on earth far exceeds human demand hence the value of wastewater is becoming increasingly understood. Many arid and semi-arid countries are now looking forward to ways of improving and expanding wastewater reuse practices. The membrane bioreactor technology has become more popular, abundant and accepted in recent years for the treatment of many types of wastewater where the conventional activated sludge process cannot cope with either composition of wastewater or fluctuations of wastewater flow rate. The membrane component uses low pressure microfiltration or ultra-filtration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank; however, some applications utilize a separate membrane tank. In this project an effort is made to compare the effluent quality of a conventional treatment plant and a membrane bio-reactor (MBR) plant. The test results revealed the superior quality of the MBR effluent over the conventionally treated effluent. A design is also put forth for a MBR treatment plant with 1 MLD capacity.**

Keywords*- *Membrane bio-reactor, conventional treatment, design of MBR

I. INTRODUCTION

In many arid and semi-arid countries water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. The total supply of freshwater on earth far exceeds human demand. The term "wastewater" properly means any water that is no longer wanted, as no further benefits can be derived out of it. About 99 percent of wastewater *is* water, and only one percent is solid wastes. For the last three decades or so, the benefits of promoting wastewater reuse as a means of supplementing water resources and avoidance of environmental degradation have been recognized by national governments. The value of wastewater is becoming increasingly understood in many countries and now looking forward to ways of improving and expanding wastewater reuse practices. Research scientists, aware of both benefits and hazards, are evaluating it as one of the options for future water demands.However, when the water supply links with better quality of treated effluents, engineering solutions were implemented that include the development of other advanced technologies like the membrane bioreactor system (MBR) which proves to be more efficient than the conventional treatment system.

A.*Sewage Treatment with Membrane Bioreactor (MBR) Technology*

The MBR process is an emerging advanced wastewater treatment technology that has been successfully applied at an ever increasing number of locations around the world. This is primarily due to more stringent effluent water quality requirements, space constraints, lower operator involvement, modular characteristics and consistent effluent water quality capabilities. Due to advances in the technology and declining costs, the application of MBR technology for water reclamation has increased sharply over the past several years.

MBR technology combines biological activated sludge processes with MF/UF (microfiltration/ ultra-filtration) membrane separation for biomass retention in the treatment of industrial wastewaters and municipal sewage. The membrane provides an effective barrier to suspended solids and can replace conventional secondary clarification and potential tertiary sand filtration.The MBR system replaces conventional filtration and combines clarification, aeration, and sludge digestion into one simpler and smaller process step. Process incorporates immersing membranes directly in a process tank, thus reducing both capital and operating cost.

B. MBR Configurations

The membranes are configured in the treatment plant in one of the following forms:

External/side stream configuration: The filtration elements are installed externally to the reactor, often in a plant room. The biomass is either pumped directly through a number of membrane modules in series and back to the bioreactor, or the biomass is pumped to a bank of modules, from which a second pump circulates the biomass through the modules in series. Cleaning and soaking of the membranes can be undertaken in place with use of an installed cleaning tank, pump and pipe work.

*Internal/submerged configuration:*The filtration element is installed in either the main bioreactor vessel or in a separate tank. The membranes can be flat sheet or tubular or combination of both, and can incorporate an online backwash system which reduces membrane surface fouling by pumping membrane permeate back through the membrane. In systems where the membranes are in a separate tank to the bioreactor individual trains of membranes can be isolated to undertake cleaning regimes incorporating membrane soaks, however the biomass must be continuously pumped back to the main reactor to limit MLSS concentration increase. Where the membranes are installed in the main reactor, membrane modules are removed from the vessel and transferred to an offline cleaning tank. With the membrane directly immersed into the bioreactor, submerged MBR systems are usually preferred to side stream configuration (with the membrane situated into a pressurized external loop), especially for domestic wastewater treatment.

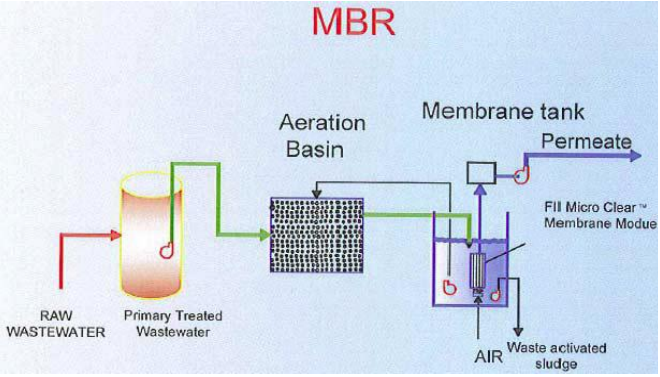

Fig.1. MBR treatment process

C. *Advantages*

- Single packaged unit, minimal civil work and pre-treatment. It is a compact system (occupies 1/2 to 1/3 the space of a conventional system) as the aeration tank size is very compact.
- Good disinfection capability, with simple filtering action causing significant bacterial and viral reductions using UF and MF membranes.
- Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing the amount of sludge produced during the treatment leading to a smaller footprint.
- Ability to operate at higher rates of production of mixed liquor suspended solids (MLSS).
- The MBR facility produces reclaimed water at a consistently high quality, regardless of variations in the quality of waste-water reaching the facility.
- The quantity of chlorine required for chlorination is significantly less than the quantity consumed at a conventional waste-water treatment facility.
- The fluctuations on volumetric loading have no effect on the system hence a high sludge capacity can be maintained.
- Sludge age and hydraulic retention time are independent.
- Superior removal of nitrogen compounds.

Disadvantages

- Higher energy consumption to operate the filtrate pumps
- Higher cost (replacement and maintenance cost)
- Higher initial investment
- Fouling is troublesome, and its prevention is costly

D.Literature Review

Islam M.A. *et.al.*,[1] shown how the mechanism of biodegradation is successfully used in conventional activated sludge processes for wastewater treatment, and also in advanced technologies as Membrane Bioreactor (MBR). The MBR systems are compared with conventional wastewater treatment systems, and the advantages of the first over the second have been clearly pointed out. Membrane fouling, membrane regeneration, the progress in the design and the application of the MBR system in the developed countries have also been briefly discussed. It is concluded that the replacement of polymeric membrane by locally manufactured filtration units in a MBR could be highly inspiring for small and medium scale industries in the developing world to build their effluent treatment plant based on MBR principle.Neha Gupta et.al.,[2]has focused on the submerged membrane bioreactor (SMBR) as a promising technology for wastewater treatment and water reclamation. This paper provides an overview of wastewater treatment in a submerged membrane bio-reactor process with a special focus on municipal wastewater systems. SMBRs predict more than 95% organic removal with relative short hydraulic retention times (HRTs) of 1-8 h and NH_3 removal of more than 90% in the municipal wastewater treatment. It achieves 30% more removal of organic matter than activated sludge process. The COD can be reduced by 95%. Nitrification was complete and up to 82% of the total nitrogen could be denitrified. Details of the various methods for washing are also included.In his article, New Trends In Waste Water Recycling with Membrane Technology- Membrane Bioreactor(MBR), K.Ravichandran [3] portrays the MBR process as a proven technology of today for treating domestic and other industrial wastewaters. MBRs produce excellent effluent quality for discharge, even with variable feed conditions. MBRs can produce water suitable for non-potable reuse or even feed to an RO system, without the need for additional filtration. Due to the older sludge age and higher mixed liquor suspended solids, the MBR process generally produces less sludge than conventional processes. MBRs can treat a higher capacity of wastewater in the same footprint as a conventional wastewater treatment plant.In the article byFenu A [4]explains that membrane bioreactors have been increasingly employed for municipal and industrial wastewater treatment in the last decade.The development of Activated Sludge Models was an important evolution in the modeling of Conventional Activated Sludge processes and their use is now very well established. The work aims to synthesize previous studies and differentiates between unmodified and modified applications of ASM to MBR. The experience reported in this review proves that, when modeling purposes do not differ from effluent characterization, oxygen demand and sludge production, ASMs are very relevant to MBR applications. Finally the outlook and future perspectives have been systematically highlighted and proposed for each section.Thomas Maere*et al*[5] explains that the benchmark simulation model for membrane bioreactors (BSM-MBR) was developed to evaluate operational and control strategies in terms of effluent quality and operational costs. The configuration of the existing BSM1 for conventional wastewater treatment plants was adapted using reactor volumes, pumped sludge flows and membrane filtration for the water sludge separation. The BSM1 performance criteria were extended for an MBR taking into account additional pumping requirements for permeate production and aeration requirements for membrane fouling prevention. A comparison with three large scale MBRs showed BSM-MBR energy costs to be realistic. In their study, Jirachotephattaranawik *et al*[6] presented that Non-biodegradable solid wastes of non-intact membranes fibres/flat sheets and modules disposed from membrane bioreactor (MBR) plants are in great concern for environmental impact. This article was aimed to propose an alternative to make uses of the non-intact membrane fibers for the aerobic biofilm supports and to study the feasibility on process operation of novel moving fibre bio film MBR. A system of moving fibre bio film MBR was designed and evaluated experimentally, including an up flow anaerobic sludge reactor, an aerobic moving bio film reactor.**Thomas Maere** et al [7] carried out cost sensitivity analysis for a full-scale hollow fiber membrane bioreactor to quantify the effect design choices and operational parameters on cost. Different options were subjected to a long term dynamic influent profile and evaluated using ASM1 for effluent quality, aeration requirements and sludge production. The results were used to calculate a net present value (NPV), incorporating both capital expenditure (capex), based on costs obtained from equipment manufacturers and full scale plants, and operating expenditure (opex), accounting for energy demand, sludge production and chemical cleaning costs.Results show that the amount of contingency built in to cope with changes in feed water flow has a large impact on NPV.

II. EXPERIMENTAL STUDY

A. Field Study-Conventional sewage treatment plant

Location: Belicia sewage treatment plant, R.A. Puram

Influent type: Domestic sewage- toilet waste

Plant capacity : 150 KLD

Average daily flow : 65-85 KL

Maximum daily flow : 90-130 KL

Hydraulic retention time: 25 hrs

The raw sewage which includes the toilet waste from the TVH-Belicia Towers initially moves into the aeration tank from the collection tank. The sewage then undergoes purification in the clarifier, primary sand filter, activated carbon filter where tertiary treatment takes place before it moves into the treated water tank. The sludge from the clarifier is moved into the sludge holding tank and the sludge drying bed and the dried sludge is then disposed. The recyclable water from the sludge tank is again allowed into the aeration tank.

B. Membrane bioreactor sewage treatment plant

Location: Nokia Plant, Sriperumbdur
Influent type: Domestic Sewage- Toilet and Canteen Waste
Plant capacity : 1 MLD
Average daily flow : 0.3-0.5 ML
Maximum daily flow : 0.6-0.8 ML
Hydraulic retention time: 10 hrs
Membrane configuration: Side stream configuration
Treatment methods: Pre-treatment, Aeration and Membrane bioreactor.

The raw sewage from the Nokia plant which includes both toilet and canteen waste from the plant first passes through the screens and then into the equalization tank. The water from the equalization tank moves into the aeration tank where there is production of mixed liquor suspended solids (MLSS). The water then undergoes purification in the membrane where the water becomes suitable for reuse and is stored in the treated water tank. The sludge is collected from the aeration tank and is dried to be disposed.It is observed that the treatment procedure has a very limited number of stages and the amount of sludge production and disposal is much less than in the conventional treatment.

III. RESULT ANALYSIS

Samples from TVH-Belicia towers and Nokia Plant were collected and tested for the seven sewage parameters namely

1. pH value
2. Total suspended solids
3. Total dissolved solids
4. Chlorides
5. Sulphates
6. COD
7. BOD
8. Oil and Grease

From the test results the percentage purification for both the samples are evaluated and the results are tabulated in Table 1.

TABLE 1: PERCENTAGE PURIFICATION IN CONVENTIONAL & MBR SYSTEM

PARAMETER	% PURIFICATION IN MBR	% PURIFICATION IN CONVENTIONAL SYSTEM
pH	12.63	11.61
TSS	97.78	97.14
TDS	15.63	5.56
Cl	24.51	3.65
SO_4	58	48.76
COD	100	96.40
BOD	100	98.94
Oil &Grease	98	96.67

The results reveal that the purification level in the Membrane technology was much higher when compared to the conventional system. It was observed that the BOD

and COD levels were below detectable limit in the MBR effluent.Thus it is evident from the test results that Membrane Bioreactor system is much superior to the conventional treatment system in terms of purification and ease in purification.

IV. MEMBRANE BIO-REACTOR DESIGN

The sewage treatment plant with submerged membrane bioreactor with a plant capacity of 1 MLD is designed and the dimensions of different units are given below:

A. Bar screen chamber: Screen Size = 12mm

B.Collection tank= 10.5m*11m*4.5m

C. Aeration tank = 6.75m*11m*4.5m

D. Treated effluent tank = 10.5m*11m*4.5m

V. CONCLUSION:

The highly efficient membrane bio reactor system produces high quality effluents that are almost free from solids and a BOD and COD content that completely meet the TNPCB standards. This is observed from the samples that were collected from TVH-Belicia towers which has a conventional treatment plant and Nokia plant which has adopted the MBR Technology.The sample test results reveal that the purification level in the membrane technology was much higher when compared to the conventional system. It was observed that the BOD and COD levels were 32 and 4 respectively which suits the tolerance limit as per TNPCB norms (250 and 20 respectively).

A case study of the two plants also helped to design a 1 MLD MBR treatment plant with submerged membrane bioreactors. This plant is designed with the basic intention of meeting the space constrain problems.An effort has been made to propose a treatment process to convert sewage water into potable water by undergoing ultra-filtration and chemical treatment using sodium hypochlorite and hydrogen peroxide.Thus the MBR process is a proven technology today for treating domestic and other industrial wastewaters. MBRs produce excellent effluent quality for discharge, even with variable feed conditions. MBRs can produce water suitable for non potable reuse or even feed to an RO system, without the need for additional filtration. Due to the older sludge age and higher mixed liquor suspended solids, the MBR process generally produces less sludge than conventional processes. MBRs can treat a higher capacity of wastewater in the same footprint as a conventional wastewater treatment plant. Due to plummeting costs and dramatically improving performance, water-treatment applications based on membranes are blossoming. In particular, Membrane Bioreactors (MBRs) are today robust, simple to operate, and even more affordable. They take up little space, need modest technical support, and can remove many contaminants in one step. Many case studies shown that the sewage water which is treated to be just disposed into the sea can be given a three stage treatment process to be converted into potable water. When such treated effluent with just disposable standard can be treated to produce potable water, sewage treated using MBR technology with reusable standards can definitely be converted into potable water.

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