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Performance of a full-scale membrane bioreactor Technology for hostel wastewater treatment for reuse purposes

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ABSTRACT

Membrane Bio Reactor (MBR) system, designed to achieve high quality effluent within a small overall footprint. The MBR process utilises the well proven activated sludge process, but replaces conventional final settlement with an ultrafine membrane which effectively filters the final effluent. Membrane bioreactors (MBRs) can be broadly defined as systems integrating biological degradation of waste products with membrane filtration. They have proven quite effective in removing organic and inorganic contaminants as well as biological entities from wastewater. Advantages of the MBR include good control of biological activity, high quality effluent free of bacteria and pathogens, smaller plant size, and higher organic load rates. The quality of the MBR permeates for hostel wastewater conforms largely to the microbiological standards for reusable (e.g. flushing, cleaning, and agricultural use). In this study was undertaken to determine the efficiency of the MBR treatment plant in terms of its physical, chemical and biological characteristics of influent and effluent wastewater. The removal efficiencies of treatment plant (Turbidity>99%, TSS>98%, BOD>96%, COD>93% and MPN>99%) is very high comparison to another treatment plant. Membrane technology is the most important method in achieving the objective of reuse of wastewater in an era of water scarcity in many parts of the world.

Keywords - MBR- Membrane bioreactor, waste water treatment, recycle and reuse

I.INTRODUCTION

The increasing shortage of water resources and the need to preserve the primary source for drinking purposes has increased interest in the reuse of treated wastewater for irrigational (crops destined for food production, green areas or areas designated for recreational/sports activities), urban (fire protection systems, vehicle washing, street cleaning) or industrial purposes (recirculating cooling towers). One of the major problems of water reclamation and reuse is the risk of exposing the public to the chemical and microbial contaminants present in treated wastewater. In order to minimize the potentially negative impact on public health, reclaimed water quality is regulated by international guidelines [1]. The membrane bioreactor (MBR) process has attracted increasing attention in recent years as an alternative advanced treatment for municipal wastewater. MBR is a modification of the activated sludge process that utilizes microporous membranes for solid/liquid separation in lieu of secondary clarifiers. MBR technology thus integrates biological degradation with membrane filtration, ensuring effective removal of organic and inorganic contaminants and biological material from municipal and industrial waters [2].

The advantages offered by membrane bioreactor (MBR) technology have been recognised for some time. An MBR comprises a conventional activated sludge process coupled with membrane separation to retain the biomass. Since the effective pore size is generally below 0.1 μm [11], the MBR effectively produces a clarified and substantially disinfected effluent. In addition, it concentrates up the biomass and, in doing so, reduces the necessary tank size and also increases the efficiency of the biotreatment process. MBRs thus tend to generate treated waters of higher purity with respect to dissolved constituents such as organic matter and ammonia, both of which are significantly removed by biotreatment. Moreover, by removing the requirement for biomass sedimentation, the flow rate through an

MBR cannot affect product water quality through impeding solids settling, as is the case for the conventional process, although severe hydraulic and organic shock loads can be onerous in other respects [3].

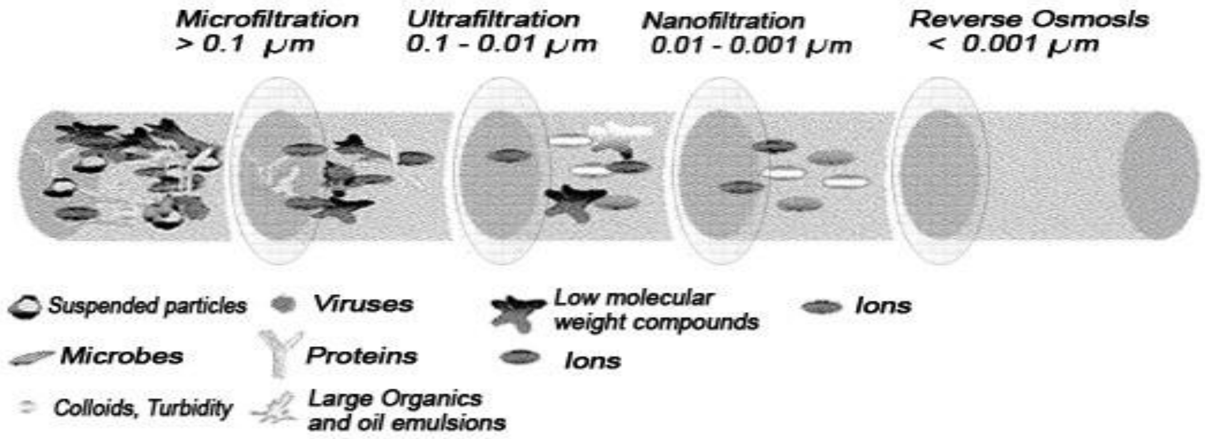

Figure.1 Membrane filtration types

Membrane bioreactor (MBR), a combination of biological degradation by activated sludge and direct solid liquid separation by membrane filtration, is an attractive alternative to the conventional activated sludge process (CASP) for the treatment and reuse of industrial and municipal wastewaters. A significant increase in MBR application is anticipated due to more stringent effluent regulations and water reuse initiatives. However, the wide spread application of the MBR process is constrained by challenges including membrane fouling, pretreatment, membrane lifespan, cost and plant capacity. Among these challenges, membrane fouling is considered as a major limitation to faster commercialization of MBR technology and is considered as the most serious problem effecting system performance. Membrane fouling can be attributed to the adsorption of soluble organics and biopolymers, the attachment of microbial cells and fine particles and deposition of inorganic precipitates on the membrane surface [4]. To date the greatest challenge in MBR operation is overcoming the serious problem of membrane fouling Several methods have been used to alleviate membrane fouling in MBRs by modifying membrane materials, optimizing operational conditions and improving sludge properties of mixed liquors[5,6]. Fouling of membranes in MBRs is a very complex phenomenon with diverse relationships among its causes, and it is very difficult to localize and define membrane fouling clearly. The main causes of membrane fouling are:

- Adsorption of macromolecular and colloidal matter
- Growth of biofilms on the membrane surface
- Precipitation of inorganic matter
- Aging of the membrane

As a measure of fouling, resistance (*R*), which is inversely related to *K*, is often used. *R* is given by:

$$R = \frac{\Delta P}{\eta J}$$

sWhere η stands for permeate viscosity in ($kgm^{-1}s^{-2}$) and J stands for Permeate flux in($L\ m^{-2}\ day^{-1}$). The flux is related to its driving force which is transmembrane pressure (TMP or ΔP) while the membrane performance can be estimated from the membrane permeability (K), which is calculated as permeate flux per unit of TMP and is usually given as $L\ m^{-2}\ h^{-1}\ bar^{-1}$. This total filtration resistance consists of a number of components, which can be divided as: membrane resistance, resistance of the fouling layer on the membrane surface, and resistance offered by the membrane-solution interfacial region and backwashing of membrane, tank stores enough permeate to allow the membrane to be flushed for a short period in the opposite direction of the process filtration. The latter has the effect of flushing the membrane surface of solids build up and fouling before being returned to process mode [7].Trans-membrane pressure (TMP) was recorded using a vacuum meter to monitor the evolution of membrane fouling. When the value of the vacuum meter reached 35 kPa, the membrane module was removed for cleaning. Chemical cleaning was done by soaking the membrane modules in solutions of 1% hydrochloric acid for 2 h and 0.2% sodium hypo chloride for 12 h. No excess sludge was discharged during both MBRs' operation, except for samples taken out to measure the suspended solids [8].

Benefits of MBR:

- The membrane is an extremely effective solids separation device.
- High removal efficiency results in a very high effluent quality.
- Simplicity of system design.
- Water re-uses application

II.MATERIALS AND METHODOLGY

2.1 Membrane Configuration

The MBR systems are of two types submerged configuration (membranes are placed inside the bioreactor tank) and external configurations (placed outside the tank). In a submerged configuration, the membrane module is submerged in aeration basin and and the filtration is done by suction removal of effluent by pumps . The external configuration is pressure driven filtration and is more prone to membrane fouling than submerged MBR due to high permeate flux. The transmembrane pressure (TMP) varies from 1-4 bar and permeate flux varies from 50-120 $L/h.m^2$ in external configuration while in submerged configuration TMP is around 0.5 bar and permeate flux varies from 15-50 $L/h.m^2$ [9]

2.2 Membrane Materials

Membranes are usually made from ceramic and organic polymer materials but metallic membranes also exist. The most widely used commercially successful membranes are made from cellusloses,polyamides,polysulphone and polymeric substances such as polyvinylidene difluoride (PVDF) polyacrylonitrile (PAN), polyethylsulphone (PES), polyethylene (PE), and polypropylene (PP). These polymeric membranes have good chemical and physical resistance [9].

2.3 Sampling Materials and Methods

The experimental method consisted of collection of composite samples of raw sewage and treated water from the inlet and outlet of MBR plant in a one liter bottle. Sampling was conducted from 9 am to 2 pm which has peak sewage flow for 4 months (September, 2017 to December, 2017).

The efficiency of MBR treatment was examined by conducting tests in laboratory on samples and measuring changes in concentration of the total amount of organic matter in terms of BOD, COD, suspended solids (SS), turbidity and MPN of raw sewage and treated water. The samples of raw sewage and treated water collected from the outlet is shown in figure below

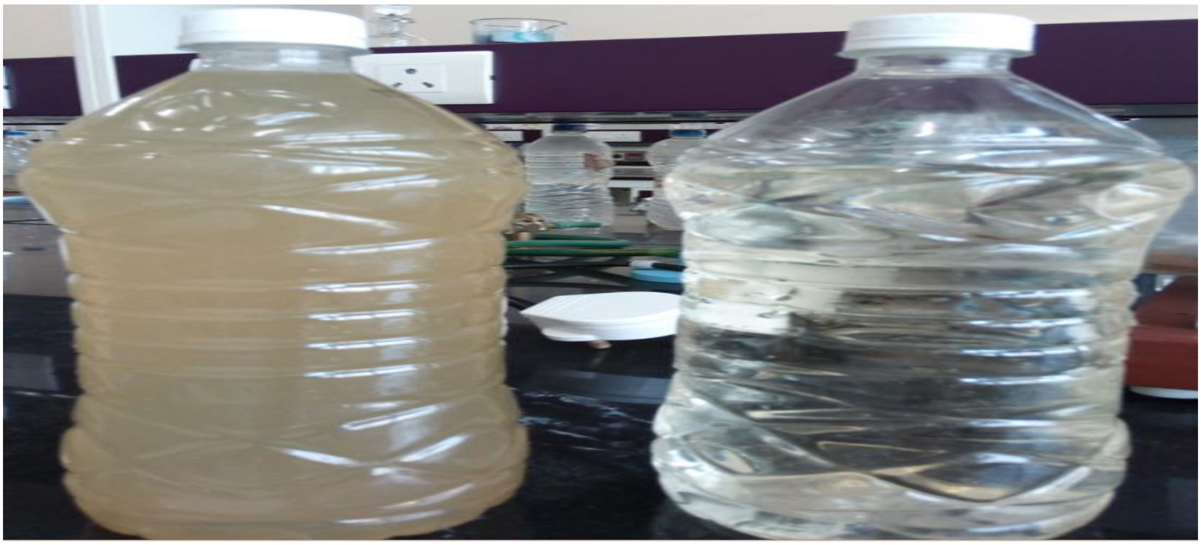

Fig. 2: Sample collected from inlet and outlet of MBR plant

2.4 Laboratory Analysis

All measurements were conducted in Environmental Engineering laboratory of Manipal University Jaipur. Laboratory analysis conducted is given in Table 1.

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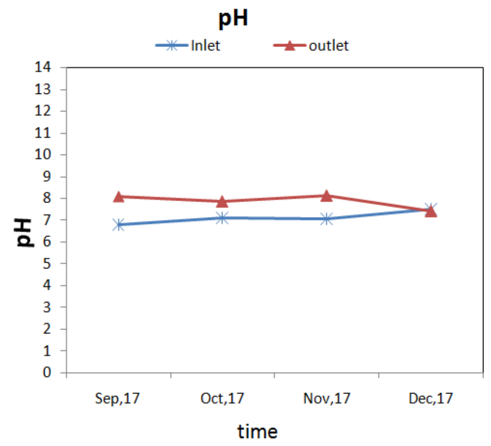
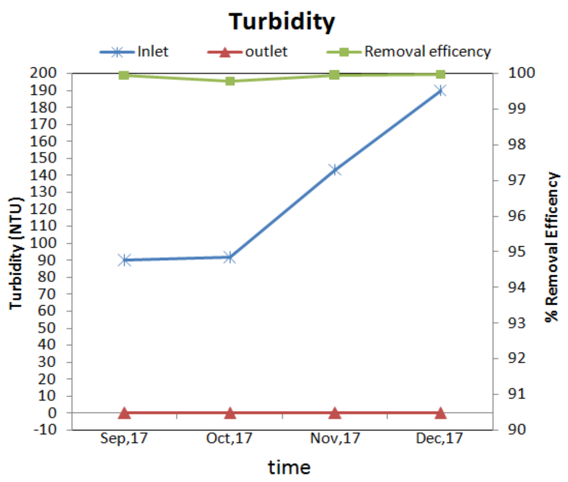
Table 1 Laboratory Analysis Methods

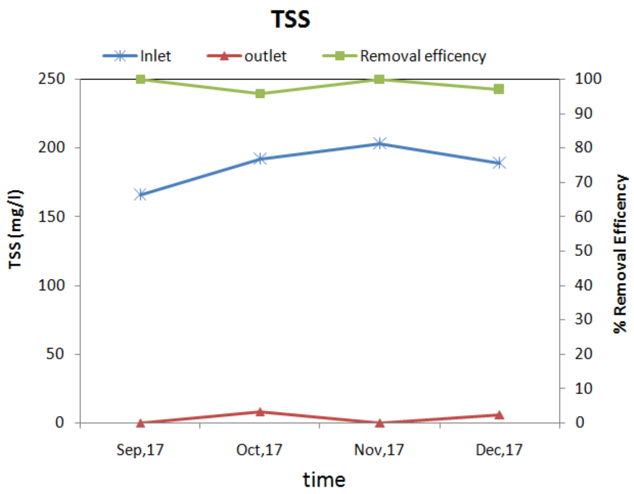
PARAMETER	*METHOD*
pH	*pH meter*
COD	*Open reflux*
BOD	*Winkler method*
TSS	*Gravimetric Method*
Turbidity	*Digital turbidity meter*
DO	*Winkler method*
Microbiological (MPN)	*Multiple tube fermentation test*

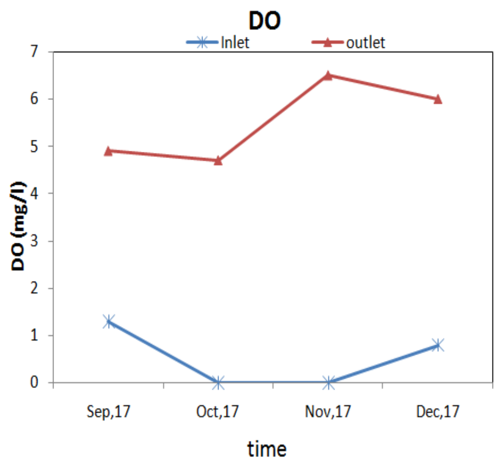
III. RESULTS AND DISCUSSION

Raw Sewage and Treated water characteristics Based on the laboratory analysis conducted on the inlet and outlet samples for different primary parameters following results were drawn from the study.









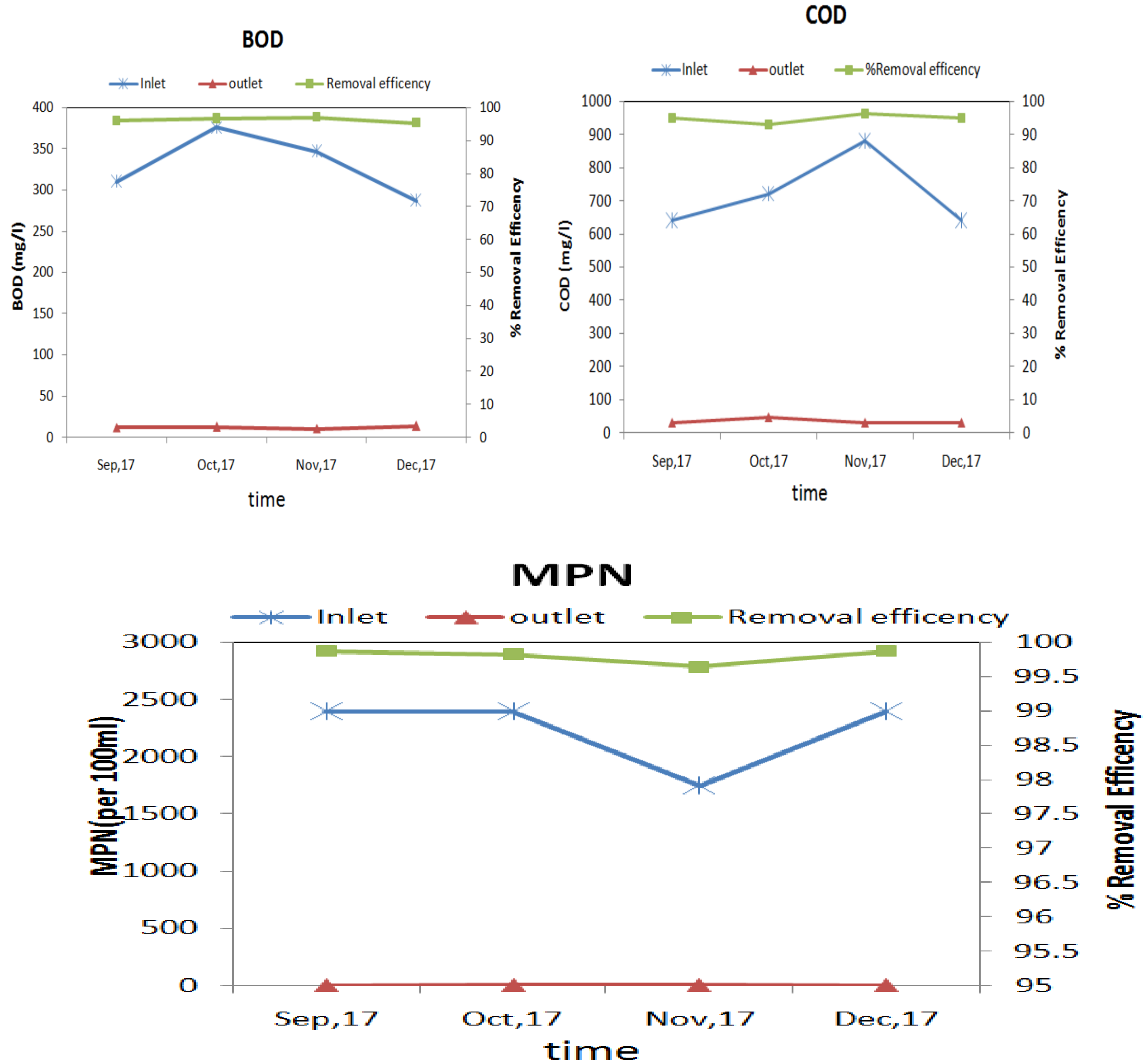


Fig. 3: graphical representation (avg. monthly data) of inlet, outlet and removal efficiency of hostel waste water with different parameters (pH, turbidity, TSS, DO, BOD, COD and MPN)

The average influent and effluent quality of the MBR system during the study period is illustrated in fig.3 (graphical representation). The pH of the inlet and outlet varied from 6.79 to 8.1 and turbidity concentration at inlet was found to vary from 89.9 to 190 NTU and outlet varied from 0.03- 0.2 NTU. The efficiency of removal of turbidity is more than 99% that's indicates good quality of outlet. The BOD of the inlet samples varied from 286- 376 mg/L while that of outlet samples varied from 10-15 mg/L. The efficiency of BOD removal fluctuated from 95-96% during sampling period. The COD concentration at inlet was found to vary from 640 to 880 mg/L while the COD concentration at outlet varied from 32- 48 mg /L. The removal efficiency of COD varied from 93-95%. And MPN removal efficiency of more than 99% that's indicates MBR process can achieve a high reduction of microorganisms. The higher removal efficiency achieved by MBR technology, particularly for virological indicators, has important implications especially if an excellent quality is required to employ effluent for irrigation, street cleaning, toilet flushing, and secondary industrial reuse

IV.CONCLUSIONS

The results of this study (performance of a full-scale membrane bioreactor technology for hostel wastewater treatment for reuse purposes)**,** indicate that the removal efficiencies of treatment plant (Turbidity>99%, TSS>98%, BOD>96%, COD>93% and MPN>99%) is very high comparison to another treatment plant and it results prove that the MBR process can achieve a high reduction of microorganisms, COD and TSS in municipal wastewater treatment and that the MBR permeate is suitable for urban and agricultural reuse. The operational experience with full-scale MBRs indicates that this relatively new technology poses a challenge to the water utilities. Many areas such as fouling control, pre-treatment, maintenance, and operators training have to be established in the operational procedures and drawbacks are expected in the uptake of this technology, which define the need for more intensive and practitioner-oriented research on MBRs.

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