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Comparative Study of Membrane Bio-Reactor with Conventional Method (Sewage Treatment Plant) – A Review

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ABSTRACT

MBR is an efficient technology for municipal and industrial waste water treatment and reuse of waste water in substantial buildings. MBR is combination of membrane filtration includes ultra-filtration and micro-filtration and biological activated sludge process. MBR proposed many advantages over conventional MBR. The major drawback inhibiting wider application of MBRs is membrane fouling which particularly resulting in exceptional increase maintenance and operating cost, reduces membrane performance and lifespan. The advanced methodology aims to minimize both operating/capital expenditure, fouling control and the key parameters considered were: mixed liquor suspended solid concentration, solid retention time, hydraulic retention time in membrane tank, MBR was developed on the basis of simulation and experimental results, flow of sludge being recycled from the membrane module to the anaerobic reactor, 20°C-standerdised critical flux and specific gas demand per square metre of membrane area. MBR WWTP operate at 15-30°C. The best porosity range for MBR is 55-60%.

***Key Words:** Solid Retention Time; Hydraulic Retention Time; WWTP; Membrane fouling; MF & UF; Porosity.*

1. INTRODUCTION

In Metropolitan areas waste water is generally treated by using traditional activated sludge processes (CASP`s), which involve heterotrophic bacteria (i.e. activated sludge) in an aerated bio-reactors which genesis the natural biodegradation of pollutants. By the application of gravitational settling activated sludge could be separated. The treatment efficiency is habitually restricted by the complications in separating suspended solids (SS`s). Which obtrude large size of aerated bio-reactor because the optimal sludge concentration is ordinarily up to 5 g/l. Further treatment of sludge requires to be assigned particularly MBR is an advanced technology of CASP where run-of-the-mill secondary clarifier is replaced by a membrane unit for the separation of treated water from the mixed solution in the bio-reactor (Zhang et al. (2013)).

A design methodology was progressed on the basis of simulation, knowledge and operation experience obtained from an AnMBR plant promoting industrial-scale hollow-fibre membranes that fed with wastewater from the pre-treatment of a municipal WWTP (Waste Water Treatment Plant). To reduce total annual costs the recommended methodology focuses on it, which are defined as the sum of capital and operating expenses (CAPEX/OPEX).

Objectives to decreased total installation reactor space for waste water treatment plant. Minimize production of excess sludge, since low yield of anaerobic microorganism. Minimize or decrease energy dissipation because aeration is not required. Recovery of potential resource because nutrients and energy i.e. Biogas production can be generated from the anaerobic degradation process. To optimize various design parameters such as MLSS, SRT & HRT (Ferrer et al. (2008)).

2. TYPES OF MBR

2.1 External/Side-stream

In this type of MBR the membrane modules are placed outside the reactor as shown in fig 1. In this type of reactor system, in external membrane module the mixed liquor from the reactor is forced. Side-stream MBRs are also commercially applied in industries as these need l these MBRs sink more energy and require extra space and also need more frequent cleaning. As including, the high cost of building cross flow membrane system because of high pressure to hold membranes in themes membrane area compared to submerged MBRs and work better for high strength wastewater with poor filterability (Geramin (2007)).

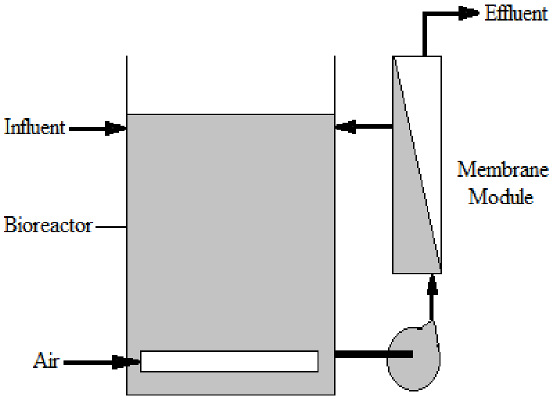

Fig 1.External/side-stream MBR

2.2 Internal/Submerged

In the submerged or immersed or internal membrane MBR system as shown in fig 2, the membranes are directly submerged in the bioreactor mixed-liquor, ideally placed compartments or individual tank integrated to the bioreactor to reduce membrane cleaning efforts. In iMBR, air scrubbing of immersed membrane decrease membrane fouling. The specific energy needed per infiltrate volume is lower than one tenth of that of cross-flow side-stream filtration (Geramin (2007)).

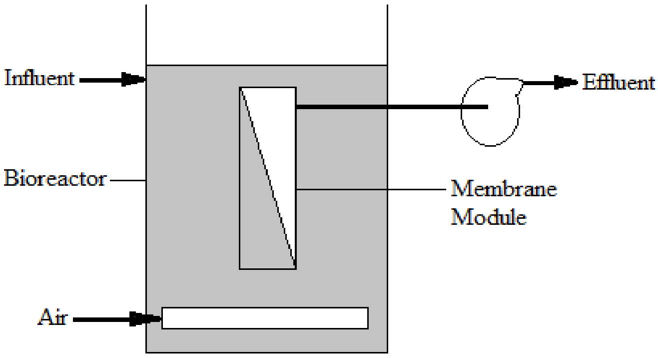

Fig 2. Internal MBR

3. MATERIALS

3.1 Materials for Membrane Designing:

There are three types of membrane materials are used:

1) Flat sheet (FS)
2) Hollow Fiber (HF)
3) Multitude (MT)

Dispersion of membrane material into the three membrane arrangements is given as follows: Which are PVDF (Plovinyldene Flurides), PES (polyethylsulphone), polyolefinic (either polyethylene or polypropylene), PTFE (polytetrafluoroethane) etc (Ferrer et al. (2008), Germin (2007), Guglielmi et al. (2007), Gujer et al. (1999)).

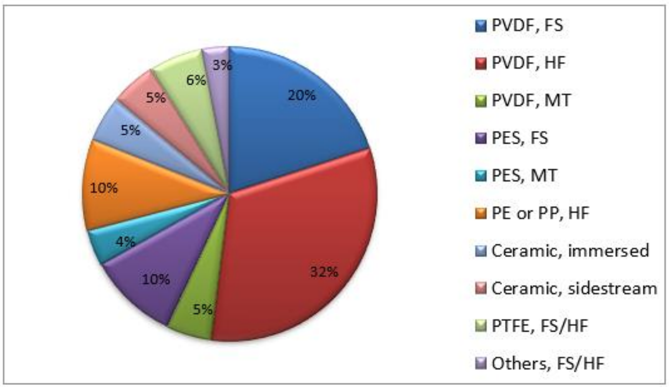

Fig3.Configuration of Various Membrane Materials

4. METHODOLOGY

In the suggested methodology, HRT, SRT and MLSS are the key operating parameters when designing the biological process in AnMBR technology, and J20, SGDm and MLSS are the key operating parameters when designing the filtration process in AnMBR technology. For designing of AnMBR the comparison of WWTP with or without MBR are represented by the f0llowing figures 4 and 5 (Guglielmi et al. (2007), Gujer et al. (1999)).

4.1 Conventional WWTP or WWTP without MBR:

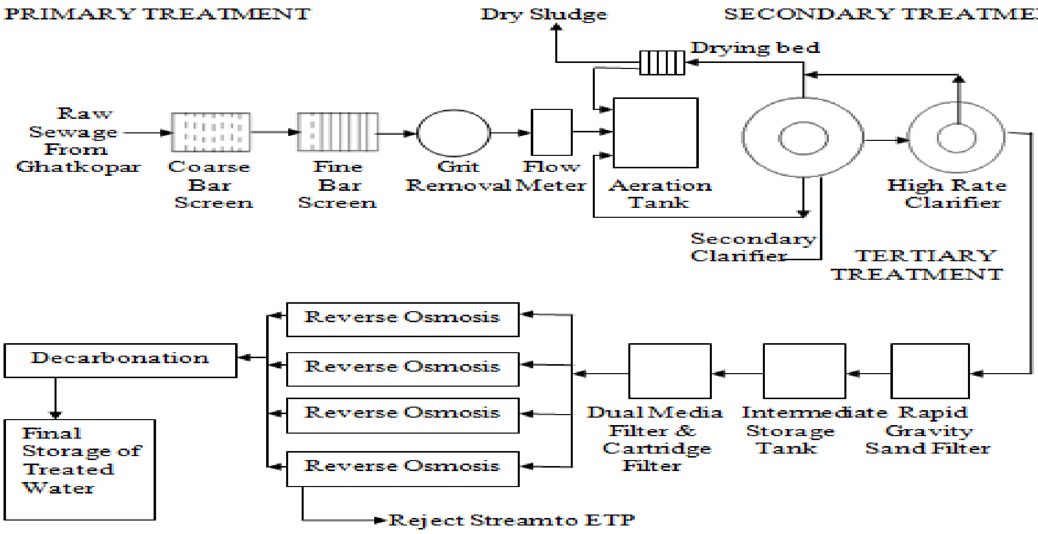

Fig.4. Process Flow Diagram of Sewage Treatment Plant without AnMBR

4.2 WWTP with MBR (AnMBR):

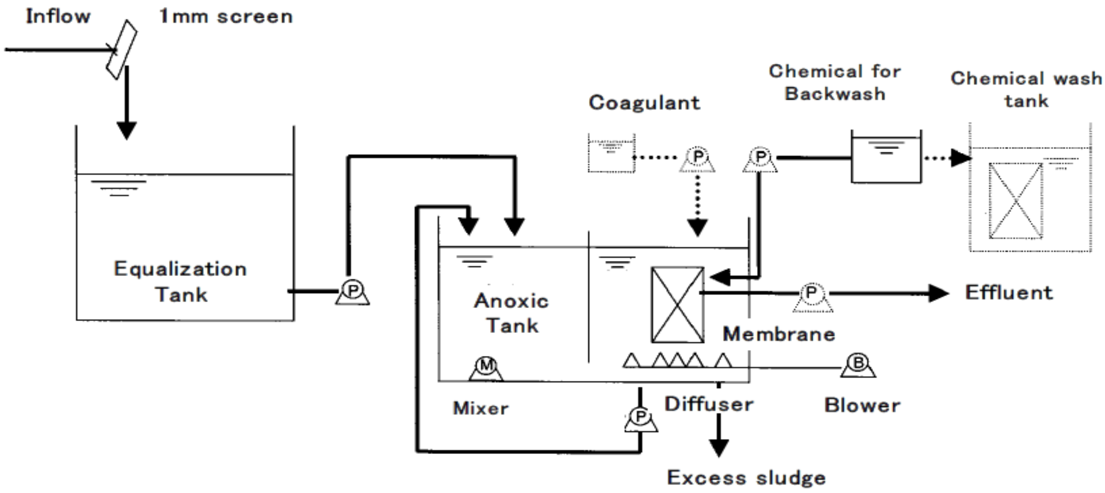

Fig.5. Process Flow Diagram of Sewage Treatment Plant with AnMBR

4.2 Biological process design:

Biological process design includes: anaerobic reactor volume, sludge recycling flow rate, biogas production, and flow rate and characteristics of the wasted sludge (Judd (2002) and WRC Report (1992)). The higher sludge recycle flow rate and the lower the reactor volume at a given at given SRT and MLSSMT can be calculated by using following equation:

$$\frac{V}{V'} = a + \frac{b}{R_{rs}} - \frac{c}{{R_{rs}}^2} + \frac{d}{{R_{rs}}^3} \quad \dots\dots\dots\dots(1)$$

Where,
V = Volume of Reactor;
V` = Reference reactor volume obtained for Rr= 1;
Rrs = Ratio of recycling sludge;
a = b = c = which are parameters of Fine-tuning.

4.3 Filtration Design

Filtration design includes: membrane area, membrane tank including blowers and pipes, biogas sparging, permeate pumping (including equipment and energy requirements), chemical reagent and membrane replacement.

Membrane filtration area is calculated by using equation:

$$[Am] = \frac{Q}{[J_{20}]} \quad \dots\dots\dots\dots(2)$$

Where,
[Am] =Membrane filtration area for each MLSSMT:
Q = influent flow rate;
[J20] = 20 ºC-standardized trans-membrane flux.

Membrane permeability calculated by using following equation:

$$[K] = -a\,[MLSS_{MT}] + b \dots\dots\dots\dots(3)$$

Where,
[K] = membrane permeability for each level of mixed liquor suspended solids in the membrane tank.

Trans-membrane pressure:

$$[TMP] = \frac{[J_{20}]}{[K]} \dots\dots\dots\dots(4)$$

Where,
[TMP] = trans-membrane pressure for each MLSSMT.

Biogas recycling flow rate:

$$[Q_G] = SGD_m \,.\, [Am] \quad \dots\dots\dots\dots(5)$$

Where,
[QG] = biogas recycling flow rate for each MLSSMT;
SGDm = specific gas demand per membrane area.

$$\text{SGDm}=\frac{Q_A}{Am} \dots\dots\dots\dots(6)$$

The results gained by using above equations which are used to calculate the capital expenses of filtration process (Ferrer (2013)).

Therefore, total annual cost:

$$TAC = \frac{r(1+r)^t}{(1+r)^t - 1}\, IC + O\,\&\,MC \quad \dots\dots\dots\dots(7)$$

Where,
IC = Investment cost;
O&MC = Operating & Maintenance cost;
r = Discount rate;
t = depreciation period [9].

4.4 Treatment Systems

The treatment systems and their removals are considered in design of MBR is shown in Table 1.

- Preliminary Treatment: Screening, Grit Removal.
- Primary Treatment: Clariflocculation.
- Biological Treatment / secondary Treatment: Pre-Denitrification, Nitrification / Oxidation, Post-Denitrification, Aeration, Biological Sedimentation.
- Tertiary Treatment: Coagulation sedimentation, Sand Filtration, Fabric filtration (Kraume et al. (2005)).

Table1. Types of unit treatment systems and their removal

Treatment system Units	Removal
Screening	Paper, Metal, Rags And Plastic etc.
Grit Removal	Heavy Solid Material, Sand, Cinder And Gravel etc.
Clariflocculation	Aggregates
Denitrification	Nitrogen
Nitrification	Ammonia
Aeration	Dissolved Gases, BOD, pH Control, Odour etc.
Sedimentation	Phosphorous And Suspended Particles etc.
Filtration	Dissolved Gases, Hardness, Colour, Bacteria, TSS, TDS, BOD, COD etc.

5. CONCLUSION

A comparative study of AnMBR with conventional WWTP we analyze that the performance of MBR is greater than the conventional activated sludge processes. The resent research about the MBR estimated that the treatment of waste water with high potential to recover energy and resources from both waste waters of having high strength. AnMBR proposed many advantages, including excellent effluent quality, stable operation performance, reduction of excess sludge production, reuse of effluent, reduction of risk substances and with significant removal of contaminants, MBR is simple, reliable and cost-effective process.

For designing of MBR we are considering some parameters such as MLSS (Mixed Liquor Suspended Solids) which reducing volume of the reactor to achieve the OLR (Organic Loading Rate), HRT (Hydraulic Retention Time) lower HRT higher OLR vice versa and also higher the HRT better viruses removal efficiency, SRT (Solid Retention Time) which affects on the membrane fouling and formation of EPS.

The efficiency of the MBR filtration process is considered by the activated sludge filterability, which is evaluated by the interactions between the applied processes conditions the biomass and the wastewater.

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