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COMPARETIVE STUDY OF MBR AND CAS WASTEWATER TREATMENT SYSTEM

Pooja nair (ME Environmental Engineering, SATI Vidisha)

ABSTRACT : This Paper deals with comparison of membrane bioreactors with conventional activated sludge systems for wastewater treatment. There are many water shortage problems currently in India, some of which are more serious public concern over health and the environment combined with the increased requirements for municipalities to reuse wastewater, have created a need for new technologies that can treat wastewater to generate high quality reusable water at low cost. In several of these technologies, membrane technology could make a great contribution since membrane have the ability to produce water of exceptional purity that can be recycled for reuse in a variety of places. In this papers, several aspects of MBR are covered, with an exhaustive over view of its biological performance different configurations and hydraulics of MBR are prevented, with attention given to fouling phenomena and strategies for reducing it. Also, the high quality of MBR effluent is discussed, whereas in comparison with CAS removals of organic matter, ammonia, phosphorous, solids, bacteria and virus are significantly enhanced. Finally advantages and disadvantages of MBR aver CAS is concerned. In conclusion, MBR represents an efficient and cost effective process that copes excellently with the growing and cost effective process that copes excellently with the growing needs for transforming wastewater into clean water that can be returned to the hydrological cycle without detrimental effects. There is, therefore the growing demand for greener/sustainable technologies for reuse/recycling of wastewater and the membrane bioreactor treatment of these effluents has shown some greater potential as it is much cleaner and meet stringent discharge requirements that with other techniques.

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I. INTRODUCTION:

There are several technologies or systems that are currently in use for waste water treatment. MBR is the most recent development in waste water treatment technology which requires huge capital investment. The selection of a wastewater treatment system for any community by governmental officials can be a challenge, because there are so many components that must be taken into consideration. With the advances in Membrane technology, strategies to reduce operating costs, and increased membrane production. MBR treatment technology has become cost competitive with CAS treatment technology for situations which require lower efficient nutrient limits or water reuse. This Research expands upon prior work by examining how variations in key design, construction, and operational & maintenance cost parameters can impact the point at which one treatment system is a more cost effective process compared to the other treatment system to meet particular sets of flow variations. Treatment of wastewater by membrane technology is an established alternative, particularly in sensitive areas, water scarce regions, and in case in which wastewater reuse and recycling is required. Industries where the membrane bioreactor technology can be implemented includes chemicals, cosmetics, dairy, automotive, petrochemical, pharmaceutical, fire chemicals, pulp & paper, landfill, food, textiles etc. Several researches explored the classification, characteristics, subcategories, configurations and performance of MBR technology. The MBR applications are expected to continue to increase in wastewater treatment, with the drivers being, the need for compact plant the high desired quality of effluent, and the value of recycling the effluent quality for discharge is becoming an issue in many countries now with stringent legislation bring put in place or that will be implemented 500n, requiring the removal of most toxic compounds. These stringent conditions appear to be more easily achieved with emerging MBR technologies.

A major advantages of the MBR system as stated by Drioli and Giovno is that is can operate at a much higher solids concentration in the bioreactor than that of a CAS – mixed liquor suspended solids concentration typically in the range 8 to 12kg/l as compared to CAS that can only work at about 2 to 3kg/l because of limitations on settling.

A comparison and assessment of MBR technology verses the CAS sludge process generally highlights the following issues.

II. LITERATURE REVIEW:

Karim MA et al. (2017) explained the preliminary analytical study conducted to compare the cost effectiveness and performance of a membrane bio-reactor (MBR) versus conventional activated sludge (CAS) systems for the treating of wastewater. The design and construction cost, Operation and Maintenance (O&M) cost, and foot-print of different MBR and CAS wastewater treatment plants were collected from various states. The performance data for several parameters were collected from local MBR and CAS wastewater treatment plants. It was found from this study that based on the capital cost considerations; CAS system appears to be a better option compared to the MBR system. However, for long-term operation, foot-print requirements, and treatment effectiveness to meet more stringent effluent characteristics, the MBR system appears to be a better option over the CAS system. Based on the long-term normalized cumulative cost analysis, the MBR system is a better option for a plant operating longer than 67 years, whereas the CAS system is a better option for a plant operating less than 67 years. Therefore, for a long-term operational goal and for performance considerations, the MBR system seems to be the best option.

AlejandroGonzalez-Martinez (2016) explained the bacterial community structure of 10 different wastewater treatment systems and their influents has been investigated through pyrosequencing, yielding a total of 283486 reads. These bioreactors had different technological configurations: conventional activated sludge (CAS) systems and very highly loaded A-stage systems. A-stage processes are proposed as the first step in an energy producing municipal wastewater treatment process. Pyrosequencing analysis indicated that bacterial community structure of all influents was similar. Also the bacterial community of all CAS bioreactors was similar. Bacterial community structure of A-stage bioreactors showed a more case-specific pattern. A core of genera was consistently found for all influents, all CAS bioreactors and all A-stage bioreactors, respectively, showing that different geographical locations in The Netherlands and Spain did not affect the functional bacterial communities in these technologies. The ecological roles of these bacteria were discussed. Influents and A-stage bioreactors shared several core genera, while none of these were shared with CAS bioreactors communities. This difference is thought to reside in the different operational conditions of the two technologies. This study shows that bacterial community structure of CAS and A-stage bioreactors are mostly driven by solids retention time (SRT) and hydraulic retention time (HRT), as suggested by multivariate redundancy analysis.

Benny M. B. Ensano et al. (2016) in their paper provides a critical review about the integration of electrochemical processes into membrane bioreactors (MBR) in order to understand the influence of these processes on wastewater treatment performance and membrane fouling control. The integration can be realized either in an internal or an external configuration. Electrically enhanced membrane bioreactors or electro membrane bioreactors (eMBRs) combine biodegradation, electrochemical and membrane filtration processes into one system providing higher effluent quality as compared to conventional MBRs and activated sludge plants. Furthermore, electrochemical processes, such as electrocoagulation, electrophoresis, and electroosmosis, help to mitigate deposition of foulants into the membrane and enhance sludge dewaterability by controlling the morphological properties and mobility of the colloidal particles and bulk liquid. Intermittent application of minute electric field has proven to reduce energy consumption and operational cost as well as minimize the negative effect of direct current field on microbial activity which are some of the main concerns in eMBR technology. The present review discusses important design considerations of eMBR, its advantages as well as its applications to different types of wastewater. It also presents several challenges that need to be addressed for future development of this hybrid technology which include treatment of high strength industrial wastewater and removal of emerging contaminants, optimization study, cost benefit analysis and the possible combination with microbial electrolysis cell for biohydrogen production.

Alejandro Gonzalez-Martinez (2015) identified that autotrophic nitrogen removal technologies have proliferated through the last decade. Among these, a promising one is the membrane bioreactor (MBR) Anammox, which can achieve very high solids retention time and therefore sets a proper environment for the cultivation of anammox bacteria. In this sense, the MBR Anammox is an efficient technology for the treatment of effluents with low organic carbon and high ammonium concentrations once it has been treated under partial nitrification systems. A lab-scale MBR Anammox bioreactor has been built at the Technological University of Delft, The Netherlands and has been proven for efficient nitrogen removal and efficient cultivation of anammox bacteria. In this study, next-generation sequencing techniques have been used for the investigation of the bacterial communities of this MBR Anammox for the first time ever. A strong domination of Candidatus Brocadia bacterium and also the presence of a myriad of other microorganisms that have adapted to this environment were detected, suggesting that the MBR Anammox bioreactor might have a more complex microbial ecosystem that it has been thought. Among these, nitrate-reducing heterotrophs and primary producers, among others, were identified. Definition of the ecological roles of the OTUs identified through metagenomic analysis was discussed.

Junjun Ding et al. (2015) investigated The effectiveness of a full scale membrane bioreactor (MBR) in the removal of bacteriophages and bacterial fecal indicators from municipal wastewater was compared with that obtained by conventional activated sludge process (CASP). Somatic coliphages (SOMCPH) and F-RNA specific bacteriophages (FRNAPH) were always detected in the pre-treated effluent (mean: 6Log(10)), while phages infecting Bacteroides fragilis were not always present (mean: 3.9Log(10)). The MBR process was able to achieve respectively 2.7 and 1.7Log(10) higher reductions of SOMCPH and FRNAPH compared to CASP (significant differences: $P<0.05$). SOMCPH were found to be the most suitable indicators for assessing MBR performance, since they showed greater resistance to biofiltration than FRNAPH and a more regular distribution in pre-treated effluent than BFRAGPH. Moreover, since the traditional bacterial indicators were almost totally removed by biofiltration, SOMCPH proved to be the best indicators to evaluate the microbiological risk when MBR effluent is discharged into natural waters or reused.

Improve water quality

As part of treatment scheme, provides water for potable reuse.

Reduces wastewater discharge fees and freshwater costs, provides water for non-potable application where fresh water is in short supply.

Lower capital cost

Clarifier is not needed

Biological step can be scaled down in volume since bacteria concentration is higher.

Reduces plant space requirements

Foot print is up to 50% smaller than conventional plant

Allows for expanded capacity within existing buildings.

The specific objectives of this study are (1) to compare the costs of the treatment plant designs, construction operation, and maintenance for both MBE and CAS Systems at different plant capacities.

Then (2) to compare the performance of MBR corollaceous Biochemical oxygen demand (CBOD) Chemical oxygen demand (COD), Total suspended solids (Tss), Ammonium (NH4), total phosphorus (TP), and volatile suspended solids (VSS) data

Capacity versus cost

MBR is the best option for the lower capacity treatment plant in terms of design and construction costs this could be due to the face MBR technology is relatively new and requires careful design and membrane selection and initial investment is higher compared to the material needed fai CAS technology. Although it appears that CAS is the best option for higher capacity treatment CAS lured the design and construction costs. The main consideration should be lair the long- term performance and cost extras laud on the unroll cost for this design period.

The o2m costs for CAS are always higher compared to MBR. CAS unit cost for O&M therefore in terms O &M cats; MBR seems to be a clear choice of selection.

Foot – print versus design and construction cost

The foot print requirement for MBR are less than that require secondary clarifiers that reduce in favor of MBR that can be emphasized her is that for on aria where land is expensive, MBR would be a better option.

However, effluent qualities for the MBR system ar better than that of CAS system, and the percent for the parameters COD, Nh4 and TP, whereas differences in other parameter (CBOD5, TSS and VSS) as very negligible. Therefore it could be concluded that the performance for the MBR system is encouraging compared to the CAS system that is separated by a study conducted by wanq s memon.

The use of membranes to separate solids and treated wastewater is the main difference between MBRs and conventional activated sludge systems for which the efficiency of the final clarification step depends, mainly on the activated sludge setting properties.

MBR system can operate at a much higher solids concentration in the bioreactor than that of a CAS-mixed liquor suspended solid (MLSS) Concentrations typically in the range 8 to 12 kg/l as compared to CAS that can only work at about 2 to 3 kg/l, because of limitation on setting.

Table: 1 Comparison of MBR and CAS Systems (wang et al, 2009)

DIARY APPLICATION	CAS	MBR
WW flow (MS/ day)	600	600
Influent COD (mg/l)	5,000	5,000
Influent BOD5 (kg/day)	3,000	3,000
Recycle of treated effluent (M3/day)	0	400
Aeration volume (m3)	4,500	600
Total floor space requirement (m2)	1,500	260
Effluent COD (mg/l)	90	90
Effluent BOD5 (mg/l)	30	5
Effluent TSS (mg/l)	30	0

When compared with conventional activated sludge systems, the MBR offers much attractive advantage.

The traditional secondary clarifier is replaced by a membrane module, this module is more compact and the quality of rejected water is independent on the variations of sludge setting velocity.

The MBR allow the biomass concentrations to be higher than for traditional treatment plants. MBR investigations have been reported with biomass concentration of 20g/l (marrot et al. 2004 Jefferson et al 1999) and even as high as 30g/l (Yamamoto et al, 1989). Conventional process utilizes biomass concentrations less than 5g/l in order to avoid problems inherent to setting of concentrated flows.

Also a report attributed to cub eke et al (1995) indicates that, increasing the biomass concentration involves a reduction in the oxygen. Mass transfer rate depending on the type of wastewater and reactor used. Other advantages of this system are as follows:-

The volume of the aeration tank can be reduced since a higher concentration of biomass can be stored in the bioreactor.

The production of sludge, the disposal of which is often difficult, is decreased by a factor of 2 to 8, resulting in a reduction of the overall operating costs (marrot eta l, 2004).

The membrane bio reaction is perfectly integrated in the industrial process because the wastewater can directly be treated in situ, allowing water reuse and concomitant reduction of the manufacturing costs linked to water consumption. The results of a study by Dufusnetal (1998) was said to be the first ever comparison made of performances between membrane bioreactor (MBR) and conventional activated sludge system treatment of a chemo thermo mechanical pulping (CTMP) efficient indicating that the performance of the MBR were superior for the removals of COD, suspended solids & toxicity. The amount of lignin onto the bio sludge in the MBR was also found to be higher as compared to that inside the CAS. Gao et al. (2004) did a comparison between a submerged Membrane Bioreactor (SMBR) and a conventional activated sludge system on treating ammonia bearing inorganic wastewater. The SMBR and the CAS were compared in parallel over a period of 210 days on treating synthetic ammonia bearing inorganic wastewater under similar conditions. Their result indicated that, the SMBR which contained larger members of nitrifies was more effective and stable than the CAS in treating the synthetic ammonia bearing inorganic wastewater. Differences were also said to be observed in the microbial community in the two systems. SMPs were reported to tend to accumulate, and then biodegrade in SMBR and the sludge particle size in SMBR were reported to be smaller than that in CAS.

Ciardelliet. Al. (2000) studied the treatment of efficient of factories that use dyes. The treatment process studied was activated sludge, sand filtration and ultra filtration (UF) and reverse osmosis(RO). The study contains a technical and economic analysis of the application of membrane separation technique for the purification of wastewater targeted at their reuse. The water quality after the membrane processes is much better than that obtained conventional processes; this treated efficient can be reused at all steps of production, including the most demanding ones concerning water quality.

III. CONCLUSION

1. The treatment performance of the MBR is better than in conventional activated sludge process. A high conversion of ammonium to nitrate (>95 %) and constant COD removal efficiency (80-98 %) was achieved, regardless of the influent fluctuations.

2. Microbial analysis of permeate should the absence of bacteria indicators of contamination and parasitical microorganisms. At the same time, the membrane prevented over 98 % efficiency in the elimination of viral indicators.

3. The removal efficiencies of BOD, COD and NH_3N were ranged between 98.9 – 99.9 % and 91.00 – 100 % respectively.

4. The removal efficiency of COD was on the average as high as 97 % in which 85 % was attributed to the bioreactor and the residual 12 % result of membrane separation.
5. The average removal of NH_3-N and SS could reached 96.2 % and 100 % respectively
6. The pH of the effluent was increased by 20.1 – 39.2 % of that of the influent.

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