International Journal of Research in Advent Technology, Vol.3, No.10, October 2015
E-ISSN: 2321-9637
Available online at www.ijrat.org

Up-Gradation of Effluent Treatment Plant Using Membrane Separation Technology as a Tertiary Treatment

Mr. Ubaid A. Khan[1], Prof. S. V. Ranade[2]
Department of Chemical Engineering[1, 2], Mahatma Gandhi Mission's College Of Engineering & Technology[1, 2]
Email: ua89khan@gmail.com[1], svranade2001@yahoo.co.in[2]

Abstract- A study of Pharmaceutical wastewater treatment by Membrane technology (Reverse osmosis process) as a tertiary treatment is been presented in this paper. An effluent treatment plant operating on Conventional Effluent treatment method with an average wastewater flow of 800 KLD has been considered for study. The wastewater is analyzed for the major quality parameters of water, which includes Total Dissolved Solids (TDS), pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and Total Suspended Solids (TSS). The composite samples were collected on an hourly basis for one month. Reusable quality of treated effluent was obtained by introducing membrane technology. Two Reverse Osmosis plants of capacity 700 KLD and 300 KLD were installed along with pre-treatment with MMF and UF. Performance of reverse osmosis plant was monitored for 60 days. Parameters thus obtained for treated effluent from RO plant was well under the limit as required. The treated water was then used for cooling tower and other miscellaneous (non-potable) purposes.

Index Terms- Waste Water, Reverse Osmosis, Ultra-filtration, Multimedia Filter, Cooling Tower water.

1. INTRODUCTION

Continuous population growth, increased industrialization and reducing availability of water resources have forced to search an alternative source of water supply. Attentions have been diverted towards reuse of wastewater as a reliable source of water. More and more contaminants are identified which are difficult to be removed or disinfect by conventional treatment methods. However most of the effluent treatment plants till present date were designed to produce safe disposable water which can be discharged to the environment. Major deficiency of these conventional treatment processes (Primary & Secondary) is high capital and operational cost with no financial gain.

Implementation of recycling and reuse of wastewater concept is increasing in industries due to regulatory developments, growing financial pressure, health and environmental concerns. Presently many water reclamation and reuse projects have been undertaken. Benefits of such concept include decreased wastewater generation, savings of fresh water supply, reduction in treatment costs and sewerage charges. This can be achieved by introducing innovative membrane technology after primary and secondary treatment as a tertiary treatment.

. Appearance of membrane technology for wastewater treatment came about 30 years ago. Initially membrane was used only for desalting but later development in technologies made it possible for wastewater treatment. There has been increase in the volume of wastewater to be treated with membrane to produce high quality of water for reuse purposes. When other technologies are unable to remove contaminants membrane may be an option. They require less floor space, are more economical than other competing technologies, easy in operation and they may replace many unit treatment process with single unit.

A study on Membrane separation technology (reverse osmosis) used to produce a reusable grade water for cooling tower and other miscellaneous uses is explained in this paper.

2. OBJECTIVES OF WASTEWATER TREATMENT ARE

- Stabilization of organic matter
- To produce safe disposable waste water in the environment.
- To reclaim and reuse wastewater.

3. GENERAL DESIGN CONSIDERATIONS

Prediction of Membrane performance in reverse osmosis (RO) processes is important both in designing membrane systems and module arrangements. It is also important in choosing appropriate operating conditions to obtain a desired separation with maximum water flux.

The design variables include water characteristics (solute concentrations and diffusivities, osmotic pressure, viscosity, etc.), module hydrodynamics and flow rates, operating pressure, and fouling potential as a function of water recovery. Some of the parameters to be considered in design:

a) Solution variables:
- Suspended solids
- Dissolved organics
- Microorganisms
- Dissolved inorganics
- Sparingly soluble materials
- Organic solvents, oxidizing chemicals
- Temperature, pH

b) Minimum pretreatment requirements

c) Membrane variables:
- Polymer type and module geometry
- Pressure, flow rate, pressure loss/module
- Water recovery concentration levels
- Minimum tolerable flux and desired flux level
- Module arrangements
- Cleaning requirements

d) Membrane integration with other processes:

For well characterized feed solutions, membrane module performance can be predicted as a function of operating variables. Many approximate calculation methods exists for special conditions, but there is no exact analytical solution to all conditions. On other hand, numerical solutions can be effectively utilized to predict membrane performance. Complex feed solution with high fouling potential often requires pilot plant experiments to obtain design information for full scale plants. Fouling problems depends on the extent of pretreatment and module types.

4. MATERIALS

4.1. *Chemicals:*

Sodium Hypochlorite, Chlorine Reagent, Sodium Meta-bisulfite, HCl, Antiscalant, NaOH, etc.

4.2. *Instruments:*

Flow meter, ORP meter, pH meter, Turbidity meter, TDS meter, etc.

5. PROCESS DESCRIPTION

Wastewater from effluent treatment plant after secondary treatment was analyzed and following parameters were obtained.

Table 1. Wastewater parameters after secondary treatment.

Parameters	Readings
pH	7-8
Turbidity	20 NTU
BOD	20 ppm
COD	850 ppm
TSS	20 ppm
TDS	3500 ppm
Total Hardness	362 ppm

Membrane treatment plant for tertiary treatment include following units

Multi Media Filter
Ultra Filtration Plant
Reverse Osmosis Plant

Influent from wastewater plant of turbidity about 20 NTU flows, under gravity from clariflocculator to an intermediate feed tank from where it is pumped by a centrifugal pump through Multi Media Filter. Effluent coming out of multi-media filter has turbidity of about 10 NTU which is stored in a Ultra-filtration feed tank by passing through micron bag filters. Water with turbidity about 10 NTU is than pumped by a centrifugal pump to Ultra-filtration system. Ultra-filtration system consists of 12 no of hollow fiber membranes with 0.90mm dia. fibers. It was operated on in-to-out flow pattern. Feed was introduced from one end of the hollow fiber and permeate was collected from the central collection port. A sodium hypochlorite dosing is provided in the feed line of UF. Permeate so produced by ultrafiltration contain zero turbidity or less than 1 and are free from macro molecules with molecular weight about 10000 such as carbon black, virus, colloidal silica, albumin protein etc. Permeate was collected in RO-I feed tank and a provision of SMBS (sodium meta-bi-sulfite) is provided in permeate line to neutralize any free chlorine in order to prevent oxidation of RO membrane. In order to increase efficiency of UF an additional mode of CEB (Chemical enhanced backwash) is provided. After certain cycle of process operations when the flux is decreased to certain level i.e. about 15% of original flux, this CEB mode gets activated followed by fast flush which regains flux to almost its original flux value. In this CEB process a hypo dosing was provided along with a rest time of 1 min.

Slit Density Index (SDI) of water is consistently reduced to less than 3 allowing reverse osmosis (RO) membrane to be operated at approximately 30% higher flux than possible with a conventional lime coagulation/sedimentation/filtration process.

Filtrate from the UF units is dosed, enroute to an intermediate (RO-I feed tank), with hydrochloric acid, to reduce pH and hydrolysis of RO membranes. UF water is drawn from the storage tank by centrifugal booster pump, dosed with antiscalant and passes through a micron guard filter.

A multistage centrifugal pump drives the Reverse osmosis plant. The RO system comprises two stage trains in a 5:3 array of six element long vessels. The membrane themselves are 7.9 in. dia. x 40.0 in. long Polyamide-Urea membranes rated at 98.5% rejection. The water flows tangentially to the membrane surface. Salts and organics are rejected allowing only water to pass through. Permeate (product water) which is virtually free of all salts and virus, is stored in 35 KL reclaimed water tank.

Treated water, because of its low TDS, is used for cooling water and non-potable water applications around the plant.

The RO-I concentrate (reject or brine) is passed to RO-II feed tank. A certain amount of reject from an existing RO-III plant is mixed with RO-I reject and is fed to RO-II plant. RO-II feed water is drawn from the storage tank by centrifugal booster pump, dosed with antiscalant, acid and passes through a micron guard filter.

A multistage centrifugal pump drives the Reverse osmosis plant. The RO system comprises, single stage 3 long pressure vessels of six elements each. The membrane themselves are 7.9 in. dia. x 40.0 in. long Polyamide-Urea membranes rated at 98.5% rejection. The water flows tangentially to the membrane surface. Salts and organics are rejected allowing only water to pass through. Permeate (product water) which is virtually free of all salts and virus, is stored in 35 KL reclaimed water tank. This water was used for cooling tower and for non-potable uses around the plant.

RO-II concentrate (reject) is sent to Multi Effect Evaporator (MEE) and incinerator for further concentration and disposal.

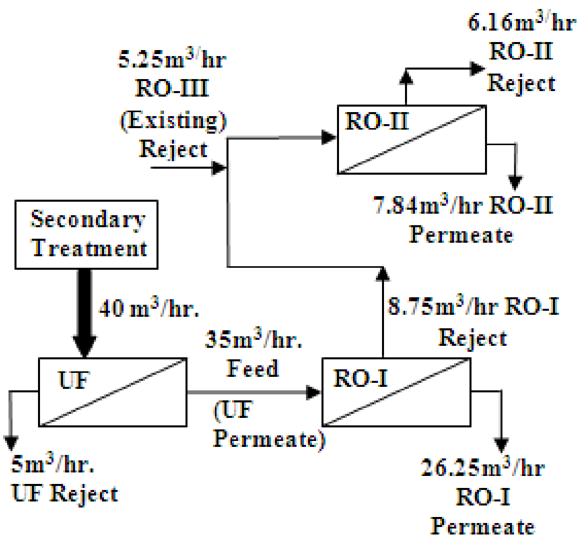

Fig. 1. Schematic process flow diagram of plant.

6. RESULTS & DISCUSSIONS

The wastewater for analysis is collected at inlet which is secondary treated and from outlet after treatment by membrane. The results of monthly analysis of pH, turbidity, COD, BOD, TDS, hardness and TSS were analyzed after treatment and compared with the standard values.

6.1. *pH*

The hydrogen ion concentration of wastewater is an important factor to be considered. Samples of feed and permeate from different points were collected to check pH using pH meter. The pH of the influent was found to be slightly alkaline and that of treated water was acidic. Treated water was neutralized later on before it used for non-potable purpose.

6.2. *Turbidity*

It is a measure of the light - transmitting properties of water which indicates the quality of wastewater with respect to residual suspended and colloidal matter. Samples of feed and permeate of UF plant was collected to check turbidity using turbidity meter. Turbidity was completely removed by pretreatment with Ultrafiltration, permeate so produced was found to be about 0 or <1 NTU.

6.3. *BOD & COD*

Samples of feed and permeate from different points were collected and sent to lab for BOD/COD analysis. It was found that BOD removal efficiency of UF was 99%. Permeate of Ultrafiltration was almost free from BOD. An additional CEB (chemical enhanced backwash) was introduced which increased the efficiency of the Ultrafiltration.
Similarly COD removal efficiency of RO was found to be 90-95%.

6.4. *TDS*

It is the amount of total dissolved solids in a water considered for analysis or treatment. Samples of feed and permeate from RO plant were collected to check TDS using TDS meter. Initially TDS of influent was about 3500 ppm and on treatment with RO it was found to be about less than 500 ppm for RO-I plant. And that for RO-II plant was less than 1000 ppm with inlet of 12000 ppm TDS wastewater.

Out of 40 m^3/hr. of secondary treated wastewater it was possible to obtain approximately 34 m^3/hr. (overall) of water with following analysis.

Table 2. Water analysis of ETP water & RO-I Permeate.

Parameters	**Treated water from ETP, Secondary treatment 40 m³/hr.**	**RO-I Permeate 26.25 m³/hr.**
pH	7-8	5
Turbidity	20 NTU	Nil
BOD	20 mg/l	Nil
COD	850 mg/l	< 250 mg/l
TSS	20 mg/l	Nil
TDS	3500 mg/l	< 500 mg/l
Total Hardness	362 mg/l	< 15 mg/l

Table 3. Water analysis of RO-II Feed & Permeate.

Parameters	**RO-II Feed** (RO-I + RO-III Reject) **14 m³/hr.**	**RO-II Permeate 7.84 m³/hr.**
pH	6-7	5
Turbidity	Nil	Nil
BOD	Nil	Nil
COD	4,000 mg/l	< 500 mg/l
TSS	Nil	Nil
TDS	12,000 mg/l	600-1000 mg/l
Total Hardness	1383 mg/l	< 30 mg/l

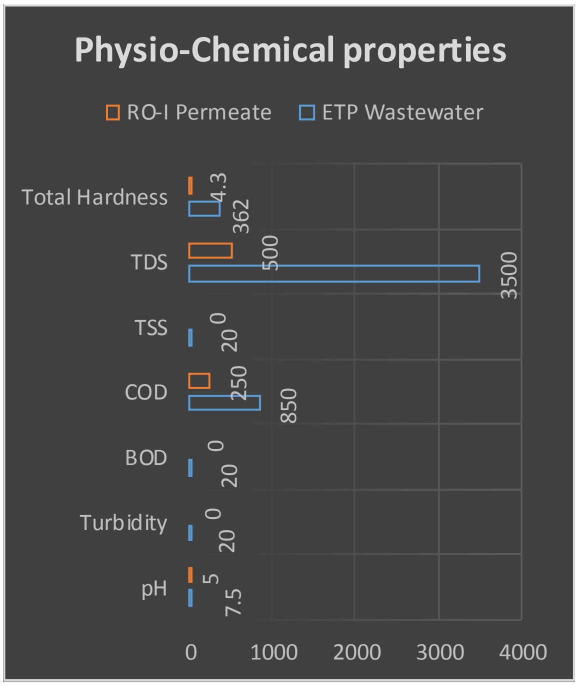

Fig. 2. Graphical representation of Physio-Chemical properties for ETP Wastewater & RO-I Permeate.

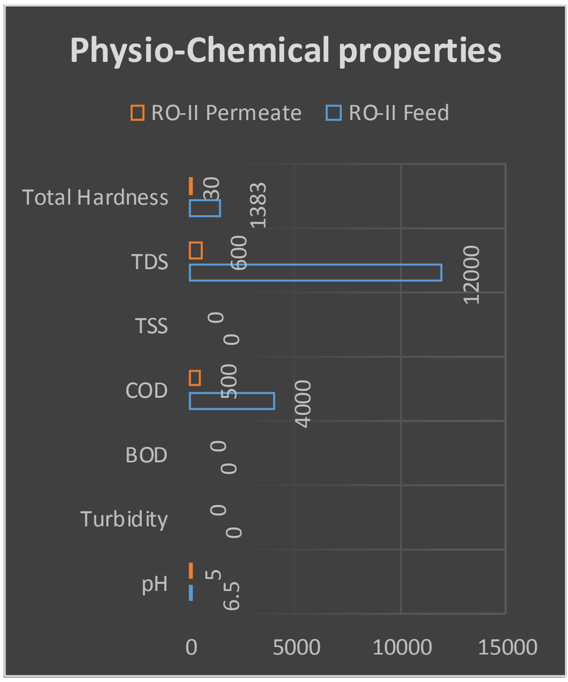

Fig. 3. Graphical representation of Physio-Chemical properties for RO-II Feed & Permeate.

7. CONCLUSION

Membrane filtration holds great promise to provide alternatives for better protection of public health and the environment. It can be concluded that, membrane technology can be successfully applied for recycling and purification of effluent or wastewater. The applications of this technology will be increased at an unprecedented scale because of its benefits. Values of physio-chemical properties of water produced after treatment by membrane technology are well below the standard values set by CPCB and are of reusable quality. Recovery of about 85-90% (approximately) of reusable quality water was achieved.

8. ACKNOWLEDGMENT

We are gratefully acknowledging to Department of Chemical Engineering, Mahatma Gandhi Mission's College of Engineering & Technology, Navi Mumbai, for experiment facility & their guidance, help in completion of this research.

REFERENCES

[1] Rashed Al-Sa'eda, Sami Sayadib, Adnan Ghatac, Hussein Abdel-Shafyd, Gerhard Schoriese, Marisol Oropezae, Antonia Lorenzof, Enrico Driolig. (2009): "Advancing membrane technologies for wastewater treatment and reclamation in selected Arab MENA countries", *Desalination and Water Treatment*, 4**,** pp. 287–293.

[2] Christopher Bellonaa, Jorg E. Drewesa, Pei Xua, Gary Amyb. (2004): "Factors affecting the rejection of organic solutes during NF/RO treatment—a literature review", *Water Research*, 38, pp. 2795–2809.

[3] Bahareh Asadollahi Esfahani, Banafsheh Asadollahi Esfahani, Mina Shams Koupaei, Seyyedeh Zahra Ghasemi. (2014): "Industrial Waste Water Treatment by Membrane Systems", *Indian Journal of Fundamental and Applied Life Sciences*, Vol. 4, pp. 1168-1177.

[4] Seeram Ramakrishna, Mohammad Mahdi A. Shirazi. (2015): "Electrospun membranes: Next generation membranes for desalination and water/wastewater treatment", *Journal of Membrane Science and Research*, Vol. 1, pp. 46-47.

[5] P.T.P. Aryanti, S. Subagjo, D. Ariono, I.G. Wenten. (2015): "Fouling and Rejection Characteristic of Humic Substances in Polysulfone Ultrafiltration Membrane", *Journal of Membrane Science and Research*, Vol. 1**,** pp. 41-45.

[6] J. Lahnsteiner, F. Klegraf, R. Mittal, P. Andrade. (2007): "Reclamation of wastewater for industrial purposes – advanced treatment of secondary effluents for reuse as boiler and cooling make-up water", Paper presented at the 6th IWA Specialist Conference on, *Wastewater Reclamation and Reuse for Sustainability, Antwerp, Belgium*, October 9-12.

[7] Craig Bartels, Rich Franks, and Keith Andes. (2011): "Operational Performance and Optimization of RO Wastewater Treatment Plants", *Hydranautics –AWWA Membrane Technology Conference*, Technical Paper.

[8] H. Strathmann (auth.), P. M. Bungay, H. K. Lonsdale and M. N. de Pinho, (Ed.) (1984): Synthetic Membranes: Science, Engineering and Applications.

[9] Georges Belfort, (Ed.) (1984): Synthetic Membrane Process. Fundamentals and Water Applications.

[10] Wes Byrne, (Ed.) (1995): Reverse Osmosis: A Practical Guide for Industrial Users.

[11] R.D. Noble and S.A. Stern, (Ed.) (1995): Membrane Separations Technology, Principles and Applications, Elsevier Science B.V.

[12] Professor K. Scott and Professor R. Hughes, (Ed.) (1996): Industrial Membrane Separation Technology.

[13] Richard W. Baker, (Ed.) (2000): Membrane Technology and Applications Second Edition. A John Wiley & Sons, Inc. Publication, California.

[14] P. Hillis, (Ed.) (2000): Membrane Technology in Water and Wastewater Treatment.

[15] American Water Works Association, (Ed.) (2005): Microfiltration and Ultrafiltration Membranes in Drinking Water.

[16] Norman N. Li, Anthony G. Fane, W. S. Winston Ho, Takeshi Matsuura, (Ed.) (2008): Advanced Membrane Technology and applications. A John Wiley & Sons, Inc. Publication.

[17] Wiley VCH, (Ed.) (2011): Ullmann's Encyclopedia of Industrial Chemistry.

[18] Ahmad Fauzi Ismail, Takeshi Matsuura, (Ed.) (2012): Sustainable Membrane Technology for Energy, Water, and Environment. A John Wiley & Sons, Inc. Publication.

[19] Rajindar Singh, (Ed.) (2014): Membrane Technology and Engineering for Water Purification: Application, Systems Design and Operation.