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SEWAGE WATER TREATMENT BY MEMBRANE PROCESS - A REVIEW

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Abstract: The need for increased water requirement for the growing population in the new century is generally assumed, without considering whether available water resources could meet these needs in a sustainable manner. The question about from where the extra water is to come, has led to a scrutiny of present water use strategies. A second look at strategies has thrown a picture of making rational use of already available water, which if used sensibly, could provide enough water for all. Membrane technology is expected to be a critical solution for such problems in the future, To encourage broader use of membrane technology through its application, mainly, in medium- to large-scale sewage treatment plants for which demand for reconstruction will increase in the future. An experimental setup of Ultra Filtration and reverse Osmosis was fabricated for treatment of Sewage water. Physical and chemical analysis of sewage Water before and after the treatment is carried out to investigate the Economic viability of the process on large scale.

Keywords: Membrane systems, Reverse Osmosis, Sewage water, Ultra filtration, etc.

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INTRODUCTION

Water scarcity is becoming a serious problem in the future, Reverse osmosis (RO) is the process that ensures highest reclaimed water quality (C. Garcia et. al). To minimize negative effects Waste water reclamation is only possible solution. Due to high quality of reclaimed water. Waste water reclamation includes Artificial ground water Recharge, Industrial Application in Semiconductor Industry and Direct Human Consumption in dilution with Fresh Water.

The Bedok Demonstration plant is one commercial plant that has successfully utilized membrane-based reclamation. This plant has operated for nearly 3 years and typically produces 10,000 m3/d of high quality treated wastewater. The low fouling membranes (LFC) purify wastewater pretreated by MF membranes. The design flux was 19 lmh with a recovery of 85%. After some fine tuning, the plant operated with very consistent performance, such that chemical cleaning of the first stage is done once every 130 days, while cleaning of the second and third stage is done once every 74 days on average.(craig et al.)

Water and wastewater treatment membranes are typically classified in order of decreasing pore size as microfiltration (MF), ultrafiltration (UF), nanofilatration (NF) and reverse osmosis (RO). As a general rule, while RO is even suitable for the removal of all dissolved species. (T. Wintgens et al)

2. WATER RESOURCES

The freshwater resources comprise the river systems, groundwater, and wetlands. Each of these has a unique role and characteristic linkages to other environmental entities. (MoEF, 2006: 28)"

2.1 Rainwater

The long-term average rainfall for the country is 1,160 mm, which is the highest in the world for a country of comparable size. Owing to physiographic factors, rainfall in India is highly variable. For example, in 2008, rainfall measured from about 500 mm in east and west Rajasthan to 3,798 mm in coastal Karnataka (CWC, 2010).

2.2 Surface water resources

Surface water resources comprise of rivers and inland water resources like lakes, tanks, canals, ponds, reservoirs, etc. They are crucial for ecosystem services as well as for providing livelihood support to a large section of the population.

2.2.1. Rivers

Of the many rivers in India, 12 are classified as major rivers whose total catchment area is 252.8 Mha. Among the major rivers.

2.2.2. Other water Bodies

Inland water resources of the country are classified as rivers and canals, reservoirs, tanks, lakes and ponds, derelict water, and brackish water. Among the remaining inland water resources, reservoirs have maximum area (2.9 Mha) followed by tanks, lakes and ponds (2.4 Mha) (CWC, 2010). Most of the area under tanks, lakes and ponds lies in states of Andhra Pradesh, Karnataka, Arunachal Pradesh and West Bengal. These states account for 56 per cent of the total area under tanks and ponds in the country (ibid.).

According to estimates, uncontrolled discharge of untreated domestic/municipal wastewater has resulted in contamination of 75 per cent of all surface water across India (MoUD, 2009).

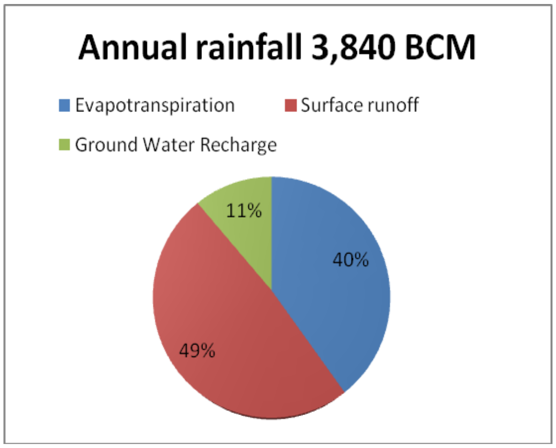
2.3 Ground water

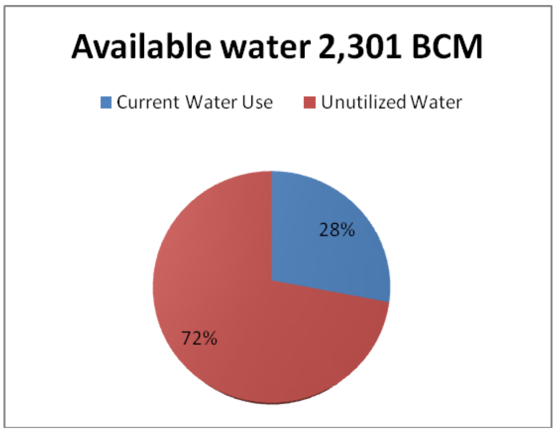
World with an estimated usage of 230 km3 per year (World Bank, 2010a). Approximately 60 per cent of the demand from agriculture and irrigation, and about 80 per cent of the domestic water demand, is met through groundwater (ibid.).

2.4 Fresh water or Drinking Water on Earth

India has about 16 percent of the world's population as compared to only 4 per cent of its water resources. With the present population of more than 1,000 million, the per capita water availability is around 1,170 m^3 /person/year (NIH, 2010).

As per the estimate of the country's available water resources , Official estimates of the Ministry of Water Resources have put total utilisable water at 1,123 billion cubic metres (BCM) as against the current use of 634 BCM, reflecting a surplus scenario (Planning Commission, 2010)





Analyzed from the source: Narsimhan (2008), cited in Planning Commission (2010: 427)

2.5 Conservation of water is Important in India.

Present estimated per capita availability of 1,588 cu m/capita/year. (CWC, 2010) India does not fall under the category of Water deficient country but can be termed as country under “water stress”

A study by Water Aid in Delhi reveals that in one particular locality, '92 per cent of water supplied goes to 20 per cent of population and the remaining 80 percent of population gets 8 per cent of the total piped water supply'. See Water Aid (2006: 58).

Also Forecast reveals that as shown in Table 1, there is immense need of conservation of water in India.

Table 1: Projected Water Demand(in BCM) for Various Sectors in India.

Sector	Report of MoWR		
Year	2010	2025	2050
Irrigation	688	910	1072
Drinking water	56	73	102
Industry	12	23	63
Energy	5	15	130
Others	52	72	80
Total	813	1093	1447

Source: GOI (2006) cited in ADB (2009:3)

3. Membrane process for treatment of water.

Membrane process for reuse of water or in other words Waste Water Reclaimation by Membrane Treatment may include following processes.

3.1 Micro Filtration

MF membranes are generally considered to have a pore size range of 0.1 – 0.2 mm (nominally 0.1 mm), although there are exceptions, as MF membranes with pores sizes of up to 10 mm are available.(steve et al.) MF is suitable for the removal of suspended solids, including larger microorganisms like protozoa and bacteria.

3.2 Ultra Filtration

For UF, pore sizes generally range from 0.01 – 0.05 mm (nominally 0.01mm) or less. In terms of a pore size, the lower cutoff for a UF membrane I approximately 0.005 mm (ibid.). UF is required for the removal of viruses and organic macromolecules down to a size of around 20 nm.

3.3 Electrodialysis and Electrodialysis Reversal

Although both electrodialysis (ED) and electrodialysis reversal (EDR) utilize membranes and are classified as membrane processes, these treatment technologies do not constitute membrane filtration. Unlike NF and RO, which use pressure to force water through the membranes while rejecting dissolved solids, the driving force for separation in ED and EDR processes is electric potential, and an applied current is utilized to transport ionic species across selectively permeable membranes. Because the water does not physically pass through the membrane in either the ED or EDR process, particulate matter is not removed. Thus, ED and EDR membranes are specifically applied for the removal of dissolved ionic constituents and are not considered filters.(ibid.)

A rough rule of thumb for the energy requirements for dernineralizing 1000 gallons of salt water by ED in large capacity plants (4 mgd) is 5 to 7 kwh per 1,000 ppm of dissolved solids removed. Since the efficiency of electrodialytic demineralization decreases rapidly with increasing feed concentrations, this process is best utilized for treatment of weakly saline (brackish) waters containing less than 5,000 ppm of total dissolved solids.

3.4 Nano Filtration

Smaller organics and multivalent ions may be removed by NF. NF membranes are also called "loose RO membranes" because they are in a broad sense, a type of reverse osmosis membrane. NF/RO membranes separate substances using the difference in their affinity to the membrane material (i.e., molecules and ions)(GIMT 2011:8); Nano filtration is also one of the Economical Membrane technology for sewage treatment but unable to separate Metal Ions, dissolved organics and aqueous salts which might adversely affect the quality of water and makes it unfit for consumption.

3.5 Reverse Osmosis.

Reverse osmosis process have been shown to significantly reduce total dissolved solids, heavy metals, organic pollutants, viruses, bacteria, and other dissolved contaminants.

Important factors in the expansion of commercial RO applications are their favorably low power requirements and the

realization of continuous technical improvements in membranes which are used in RO systems. A general guideline in water benefication is that RO is most frequently considered for cases in which the TDS is greater than 2,000 to 3,000 ppm; ED generally applies when the TDS is less than 2,000 to 3,000 ppm. However, many exceptions exist, based on feed-water species and product requirements.

Practically RO provides a complete barrier to viruses, bacteria, and other toxic entities that must be kept out of a potable supply.(Nicholas et al.)

4. Pretreatment for Waste water Reclaimation by Reverse Osmosis.

RO treatment is supposed to be replacing conventional Tertiary treatment or polishing step. Hence, It is Desirable to undergo conventionally upto secondary water treatment. And Effluent from Secondary treatment is used as Feed for RO Treatment Plant.

4.1 Chlorination:

The Secondary Treated Municipal waste water may contain many hazardous bacteria, pathogens and Viruses.

Chlorination is widely accepted economical process for Disinfection hence to Neutralize these microbes feed is firstly chlorinated by NaOCl or any other suitable chemical having free Chlorine Ions. To avoid the deposition on MF/UF surface.

4.2 Coarse Filter /Strainer:

Any Colloidal solid particle may damage the membrane surface or any other operation in the plant, hence removed in this step. It is advisable to maintain mechanism for cleaning due to coarse solid particles might clog the screen.

4.3 Micro Filtration/Ultra Filtration:

The secondary Effluent is supposed to contain coarse particles of size ranging from 10^{-2} – 9 micron result in seviour Fouling of RO Membrane. Hence, It is mentioned in most of the resourses & used in most of the Membrane Waste Water Reclaimation Facility worldwide. (F. Tang et al.)

The provision of regular chemical cleaning of Micro Filtration and Back wash with permeate can be Used.

4.4 Determination of SDI and LSI.

SDI and LSI are calculated. On the basis of these parameters a suitable quantity of Antiscalant is decided. (Doses recommended by Manufacturer of Antiscalant for calculated parameter.)

4.5 Anti Scalant Addition:

There are variety of Antiscalants are available in the market. Suitable Antiscalant (which not attack chemically to aromatic structure of polyamide membrane) is selected.

A separate tank is provided for dilution of antiscalant. There is significance of antiscalant-addition after MF treatment, as these antiscalants are supposed to be Absorbed by coarse particles which are rejected by Micro Filtration might result in wastage of them. (They are very costly).

4.6 Excess Chlorine Removal:

Residual Chlorine greater than 1mg/L in feed of RO Membrane causes Degradation of Membrane surface and causes Failure.

Sodium Meta Bisulfide is added for excess chlorine removal if any.

4.7 Cartridge filter:

This step can be taken as safety precaution, The average pore size of the the Cartridge filter available for water filtration is 0.5 micron. If due to certain circumstances their causes failure of Micro Filtration step or may be some leakage in MF Module might cause irreversible fouling of the RO membrane. Hence, this step is adopted for safety purpose

4.8 Non Oxidizing Biocide:

Non-oxidizing biocide is a highly effective microbiocide for control of slime and algae in process waters. It is EPA registered as effective over a broad

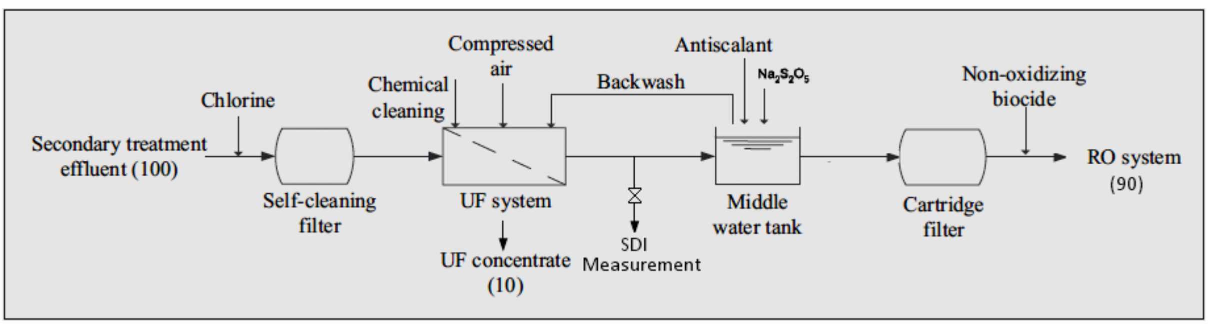


Fig. Pretreatment of RO Membrane Process for municipal Wastewater Reclaimation.
(*The numbers in the diagram indicated the proportion of the amount of water).
(Source: F. Tang et al.)

Table 2: Quality of Sewage Water after Reverse Osmosis treatment.

Source/ Parameter	RO Permeate Quality reported by Authors							IS for drinking water (IS:10500)
	(C. García-Figueruelo et al)	(L.S. Tam et al.)		(J.-J. Qin et al.)	(J.A. López-Ramírez et al.)			
	ESPA1	LFC1	ESPA1	PA	CA	PA-LP	PA-VLP	
Conductivity (µS/cm)	78.3	33	24	18.4 - 46.4	7.0	7.4	7.2	-
COD (mg/L)	7	<2	<2	-	66	53	52	-
Cl^- (mg/L)	-	-	-	-	-	-	-	0.2
$HCO3^-$ (mg/L)	37	-	-	-	-	-	-	-
$NO3^-$ (mg/L)	0.5	1.4	0.7	1.8-7.1	18.5	7.9	8.3	45
$SO4^{2-}$ (mg/L)	1.5	-	-	-	5.1	3.5	3.7	150
Na (mg/L)	12.2	-	-	-	-	-	-	-
K (mg/L)	≅0	-	-	-	-	-	-	-
Ca^{2+} (mg/L)	2.7	3.3	2.7	0.03-0.38	4.6	2.9	3.2	75
Mg^{2+} (mg/L)	0.6	-	-	-	1.0	0.7	0.7	30
TSS (mg/L)	-	<2	<2	-	0	0	0	-
TDS (mg/L)	-	24	17	-	-	-	-	300
pH	-	5.5	5.3	5.7-7.1	-	-	-	6.5-8.5
Silica(mg/L)	-	0.7	0.3	-	-	-	-	-
Total surfactants (mg/L)	-	<2	<2	-	-	-	-	0.2-1
E. coli (CFU/100 mL), % +ve	-	ND	ND	<1	ND	ND	ND	-
Virus (PFU/100 mL)	-	ND	ND	-	-	-	-	-
Ammonium-N (mg/L)	-	-	-	0.01-0.47	-	-	-	-
TOC (mg/L)	-	-	-	0.06-0.37	1.08	1.09	1.01	-
Total bacteria HPC (CFU/mL)	-	-	-	<3	-			-
Turbidity(NTU)	-	-	-	<0.1	0.2	0.2	0.2	10
Chlorides mg/L	20	-	-	-	9	6	6	250
Phosphates (mg $PO4^{3-}$ /L)	-	-	-	-	0.03	0.12	0.08	-
Nitrites (mg $NO2^-$ /L)	-	0.03	0.01	-	<0.02	0.03	0.02	-

ND, not detected

CA, cellulose acetate

LFC, low fouling composite

ESPA1, Energy Saving Poly Amide

PA, Poly Amide

PA-LP, Poly Amide Low Pressure

PA-VLP, Poly Amide Very Low Pressure IS- Indian standard Specification for drinking water.

Spectrum of microorganisms, and functions over a wide pH and temperature range. It is compatible with all types of corrosion and scale inhibitors and is effective against aerobic and anaerobic organisms Hence, to Avoid Bio-fouling this step is Adopted.

An optimized pretreatment is the key for the High performance of RO Membrane. An un-optimized or error in pretreatment leads to excess Fouling, which needs frequent Chemical cleaning, the efficiency of chemical cleaning is not 100%. That implies, compromise with Membrane Performance. Hence, Faulty pretreatment is never replaced by excess Chemical cleaning

5. Quality Of Water after Membrane treatment.

Comparative analyses of the reclaimed wastewater for reuse are performed. Analytical parameters for reclaimed wastewater quality are shown in Table 2. drinking standards were widely exceeded by the reclaimed waste water for the various membranes tested by the respected Authors. Except for pH which may be post treated by NaOH addition for pH maintainance.

The test results from the physical, chemical and microbiological study by the Authors showed that the quality of RO-permeate can meet the requirements of the drinking water stipulated in the Indian standard Specification for drinking water (IS:10500) .

6. CONCLUSION

1) Membrane Wastewater Reclaimation Technology is very efficient and Innovative technology, has ability to play key role in future Demand of Water in India.

2) RO Treated Reclaimed Water is Compatible with Indian standard Specification for drinking water

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