MBST as Eco-Friendly Technology in Management of Industrial Effluents with Recycling of Resources in Pulp and Paper Industries

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An attempt has been made to evaluate membrane based separation technology (MBST), as eco-friendly, cost-effective and appropriate technology, in recycling of water/soda chemical from pulping spent liquor, applicable to mini pulp and paper Units. Further case studies have been projected, with commercial data, for the management of bio-refractory and colour load from the bleaching and textile ayed industrial effluents.

INTRODUCTION

During the last decade, a realization has been generated, that societal consideration must shift towards ecological sustainability so as to achieve qualitative growth and industrial development within the limits of ecosystem's capacity to assimilate.

Since commercialisation of the membrance based separation technology (MBST) in mid-sixties, extensive engineering studies have been carried out, which is resulted in the emergence of MBST as a cost-effective, eco-friendly and appropriate technology in management of industrial effluents with recyling of water along with, environmental pollution mitigation.

The biggest deficiency in conventional waste treatment systems like ASP, TF and lagooning, is their inability to reclaim water for re-utilization (tertiary treatment cost being exorbitantly prohibitive) due to contamination of inorganic dissolved salts along with bio-resistant toxic pollutants. The most demanding requirement in MBST applications, in the treatment of complex industrial effluents with colloidal and non-settle-able suspended solids (SS), is the feed pre-treatment (FPT) system, for the minimization of membrance fouling and concentration polarization (CP) problems at the membrance interface. Appropriate FPT along with right type of membrance modular configuration and preventive maintenance are the critical factors to be optimised for operating the MBST plant successfully.

An attempt has been made in this paper, to evaluate the MBST system (with different variants like RO/UF/MF & ED) for the management of complex industrial effluents emanating from the following industries:

(A) Commercial operational data from two large capacity Pulp and Paper Mill (Capacity 1100-3000 TPD) in Japan for the management of recalcitrant pollutants with intense colour load, emanating from pulp bleaching plants.

(B) Schematic flow-sheet for the management of extremely high pollution load in BL and BSW plants, for recycling of water/soda chemicals along with pollution abatement emanation from Mini Pulp & Paper Plants (MPPP).

(C) Cost-benefit data of a commercial effluent management plant handling toxic effluents with water recycling from a Textile (7 TPD Knitted fabric processing plants.)

Total operational cost by UF is 1/3 to 1.4 of the Conventional ASP treatment for the management of bleaching plant effluents, containing high load of bio-resistant, and colour pollutants (not removed by the conventional ASP system)[6-7].

The above mentioned soda recovery process (SRP), amenable to the MPPP, for the regeneration black liquor (BL), was discussed and evaluated by the UNIDO, when it was presented at the UNIDO Meeting, at Alexandria, in April, 1986. In the process, concentrate from UF (after recycling UF permeate to the digester - 95% of the feed), at about 15-22%, around 1.20 m^3/T of Pulp production, can be treated in small lagoon, for solar evaporation to dried ligno-organic complex (containing over 84% organic, plus 50% of the remaining soda charged to the digester). The dried ligno-organic complex may be used as good quality boiler fuel, whereby soda can be recovered to the extent of 88-92% (including 45-50% by UF as free soda as

Table 1 (a) : Operational data for a Commercial Plant (UF) Handling Bleaching Plant Effluent from 3000 TPD Pulp & Paper Mills, Shikoku, Island, Japan.

Design & Performance Data		
Design	**Actual**	
Feed	1.05 MGD	0.980 MGD
Concentrate	53,000 Gls/D	52,000 Gls/D
COD (feed)	1,250 ppm	1,900 ppm
COD (conc.)	18,500 ppm	24,700 ppm
COD removal	75%	79-85%
Total COD removed by the plant (T/D)	3.75	5.50
Average flux (gfd)	63	57
		[1000 LMH]

Table 1 (b) : Total operational cost of the UF system is 1/3 to 1/4 of the conventional ASP treatment system

Operational Data of a Commercial Effluent Treatment Plant in a Pulp & Paper Industry (Capacity-1100 TPD) by Ultrafiltration (UF) Technology Located in Japan-Sanyo Paper Mills, Iwakuni.

Feed to the UF plant	104 m^3 / hr.
No. of modules	16(each 42m^2 membrance area)
Permeate volume	91m^3/hr.
Concentrate volume	13 m^3/ hr.
COD in feed	2200 ppm
COD in permeate	470 ppm (80%)
COD in concentrate	14,300 ppm
Power Consumption	340 kWh
Operation hours (AP 1982)	9000
Colour rejection	

Na_2Co_3).

The most critical factor in MBST for specific application in highly toxic and intensively fouling type of effluents like paper mill BL from agro-based MPPP, is the appropriate tpye of feed pretreatment.

As stated before, appropriate feed pretreatment (FPT), before it is feed to the membrance modules, is the most important factor to be considered, for successful operation of UF/RO systems. In fact, for highly fouling type of industrial effluents like Pulp & Paper, and allied industries like textile, FPT may take over 60% of the total operational cost for the management of effluents with resource recycling [9-18]

As an illustration, feed pretreatment system of a commercial plant, handling effluents from a 7 TPD coloured knitted fabric processing Unit, is demonstrated in Fig-3.

Total capital investment for the effluent recycling plant (with pollution abatement) of 7 TPD Textile fabric Unit - over 700 m^3/D washing effluent after dying, complete with FPT, MBST (RO), and multi-effect evaporation and crystallization (for salt recovery as Zero effluent discharge plant) is around, Rs. 2 crores. The savings through water Environment Sc. & Engg., March-2003,

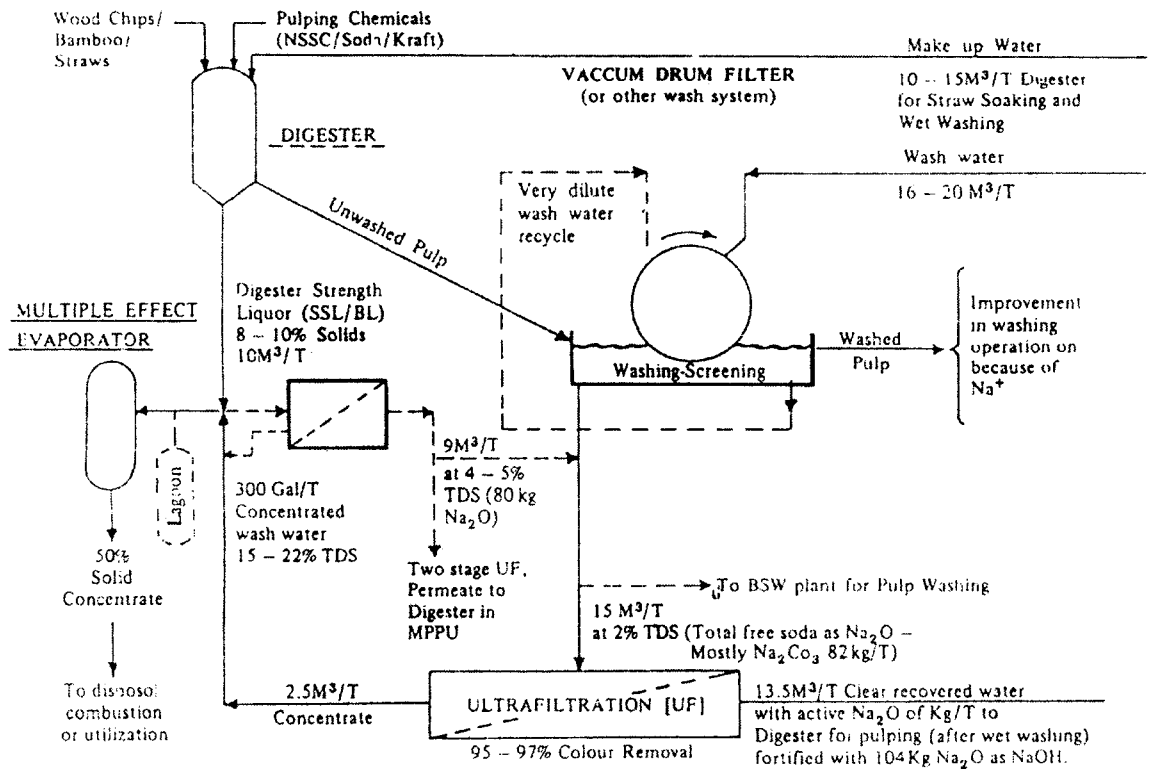

Fig. 2 : Proposed process of soda recovery and water reuse by Membrane process in paper mill

Mohonsundaram, S) Similar systems with MBST are in commercial operation at the Chennai Petroleum Refinary Plant, and NFL (Manali Estate, Chennai).

During the last two decade, extensive R & D Work have been carried out in different countries, which is resulted in the development of high performance, low fouling with enhance permeate flux at low pressure (a critical factor in reduction of capital investment requirement) along with increased service life of the membrances[1-15].

MBST as a hybrid combination with conventinal waste treatment systems gives much improved performance, in terms of reduction of operational and capital investment requirement.

In most of the hybrid combination systems, physico-chemical operations like screening, clari-flocculation-sedimentation, secondary clarification (as ASP, the most widely used industrial effluent treatment process) all these operations act as an appropriate FPT for the MBST.

A part from getting tangible benefits like resourve recycling with pollution management, the proposed hybrid combination system with MBST as the critical Unit, could give good amount of intangible benefits like quality improvement of the environment, and conservation of scarce resourves like water, which is becoming the most crucial factor in industrial development of the country.

Pollutant	Method of Removal	Equipment Used
Suspended solids and colour bodies	Clarification and chemical conditioning	Tube Settler, Chemical Dosing System
Dissolved Organic Impurities	Aerobic Treatment	1. Submerged Air Fixed Film Reactor (STAFF) 2. Trickling filter
Residual Dissolved Organic Impurities	Absorption	Column containing special purpose ion exchange resin (Organic Scavenger)
TDS removal upto 80%	Reverse Osmosis Membrane	RO Plant single stage/multi-stage
High TDS - RO reject	- Solar evaporation - Thermal evaporation	- Solar pond - Thermal Desalination Plant

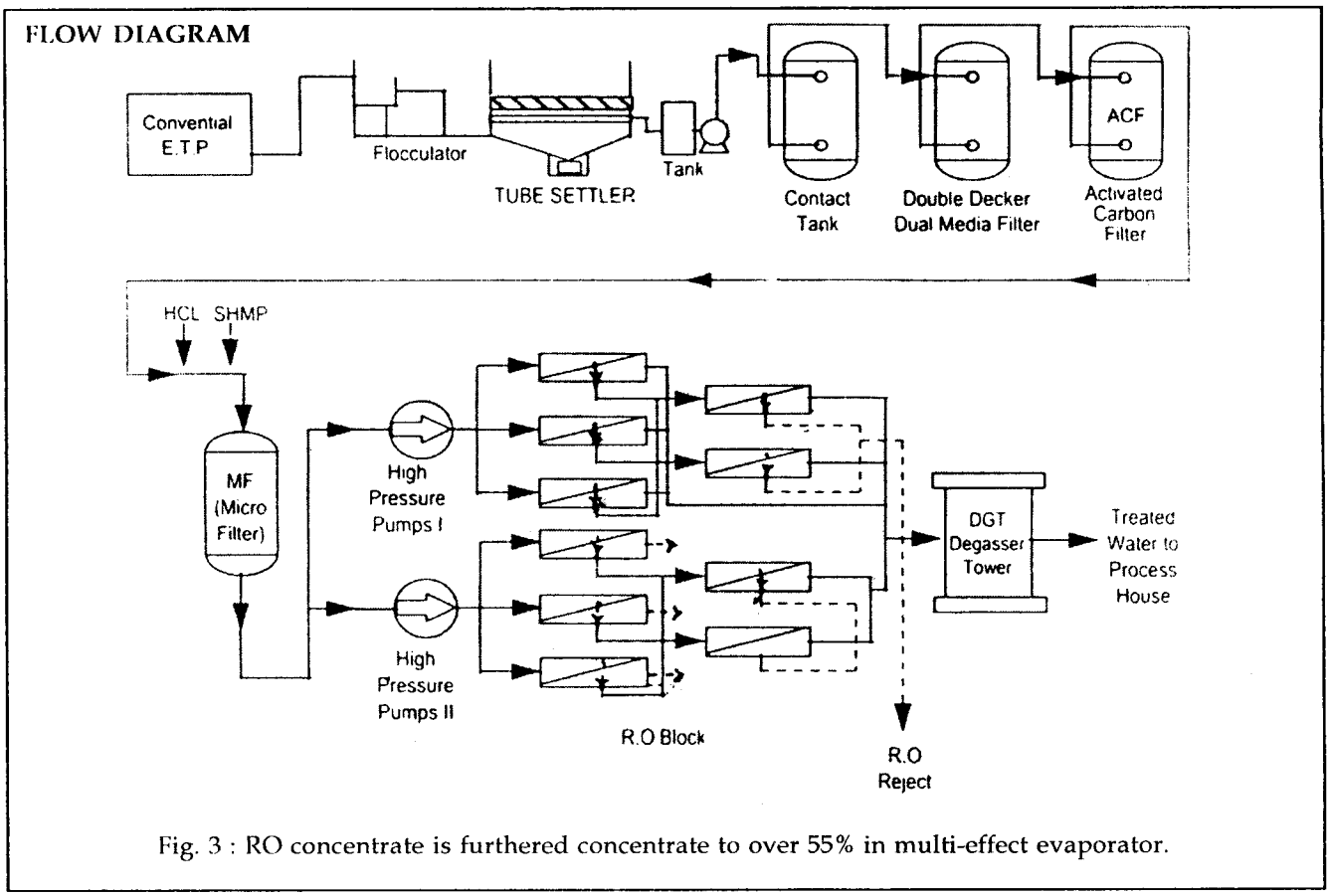

Fig. 3 : RO concentrate is furthered concentrate to over 55% in multi-effect evaporator.

REFERENCES

1. Munir Cheryan, "Ultrafiltration Handbook, Technomic Pub. C. Ltd., Basel, Switzerland, (1986).
2. Georges Balfort, "Synthetic Membrane Processes", Academic Press, New York, (1984).
3. Li, N.M., "recent Developments in Separation Sciences", CRC Press, Cleveland, USA, Vol.2-10 (1972-84).
4. Souriranjan, S. and Matsuura, T., "RO/UF process principles", NRCC Pub. No. 24188 (1985), Ottawa.
5. Lonsdale, H.K., J. Mem. Sc. Vol. 10 (1982) : 81-181.
6. Nitto Electric Co., Membrane Div., Japan, "Company Bulletin on Tale paper Mills. (1983).
7. Haagensen, U.N., DDS, Denmark Bulletin on Sanyo Paper Mills, Japan, 1924-GB-0482-50 (1982).
8. EPOC Filtration Seperation System, California, USA, "Application report on EXXFLOW/ EXXPRESS flexible turbular system for management of toxic effluents (1993).
9. S. Basu, b. Chakravorty and R. N. Mukherjee, Int. J. Envl. Studies, Vol. 27 (1986) : 173-181.
10. S. Basu, B. Chakravorty and R. N. Mukherjee, J.Mem. Sc., Vol. 41 (1989) : 155-161.
11. S. Basu and Sapkal, V.S., Desalination Vol. 67 (1987) : 371-379.
12. S. Basu and Sapkal, V.S., I. Chem. E. (London) Symposium series 113, Bradford (1989) : 131-144.
13. S. Basu and Moulik S., Desalination, Vol. 47 (1983) : 335-144.
14. S. Basu, Chemsearch & Industry, Vol. V(3), July/ Aug. (1990) : 9 - 12.
15. S. Basu, Development of soda recovery process by UF, UNIDO Project Report No. US/RAF/84/239, Alexandria, 26-30 April, 1986 : 192.
16. S. Basu, TAPPI, Vol. 57 (7) 1974 : 101-104. IPPTA, Vol. 8 (4) 1971 : 207.
17. S. Basu & V. S. Sapkal, IPPTA, Vol 20 (4) 1984 : 1 - 4.
18. S. Basu & K. Irrana, IPPTA, Vol. 19 (4) 1983 : Conv. Issue.
19. S. Basu Indian Patent No. 93799 (1964)
20. J. S. Gratzl, Kirkuman, A.G. & Edward, I.L., TAPPI, Vol. 69 (5) 1986 : 110