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MEMBRANE TECHNIQUES IN EFFLUENT DISPOSAL ALONG WITH WATER/CHEMICALS RECLAMATION

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INTRODUCTION

Although three-fourths of the Global surface is filled with water, 99% of the water is nor accessable for direct human consumption, 97% being confined to seas, another 2% being fixed-up as ice-caps in the polar regions. With much of this available water, which constitutes hardly 1% of the total Global water, being impaired due to unrestricted disposal of domestic and industrial effluents, water supply is fast becoming one of the costliest resources to sustain the industrial growth in most of the developed and underdeveloped countries of the world.

The most single deficiency in conventional waste treatment systems, based on biological or chemical conversions, is the inability of these systems to reclaim water for reutilization.

Moreover, none of these conventional waste treatment systems are addressed to the removal of inorganic solutes which contribute to the degradation of the surface or groundwater, and may inhibit the use of the water.

Against this background of grave industrial pollution, coupled with acute scarcity of water, extensive exploratory research, and engineering studies have been undertaken during the last two decades, on the development, and application of membrane technology- Electrodialysis (ED), and Reverse Osmosis (RO) - for the reclamation of water and useful chemicals, along with pollution abatement from industrial effluents in Pulp & Paper (Ref.1 - 6), Dairy (Ref 7.), Electroplating (Ref 8), Food processing industries (Ref 7.), and saline water (Ref. 9). RO and Ultrafiltration techniques as a cost effective device have been suggested by different researchers as a tertiary aid in conventional waste treatment systems for the elimination of toxic and bio-refractory pollutants from the secondary effluents along with water receovery for recycling (Ref.10).

A large quantity of wash effluents (around 25 m^3/hr per spinning machine) are generated during spinning process which remain a big pollution hazard surrounding Rayon industries. Conventional waste treatment process (based on lime preparation) requires high capital investment, with high operating costs due to non-recovery of sodium and zinc sulfates from the spinning wash effluents.

Techno-economic feasibility of Na_2SO_4/$ZnSO_4$ concentration and recovery from admixture in dilute solutions by RO technique has been suggested by several researchers recently (Ref.11, 12).

An attempt has been made in this work to demonstrate the applicability of RO technique in treatment of Rayon industrial effluents, major objectives being to evaluate the techno-economic feasibility of pollution abatement, along with water/ chemicals reclamation for recycling, from spinning process wash effluents.

EXPERIMENTAL PLANNING

Spinning wash effluent was obtained from a Rayon manufacturing plant at Kalyan near Bombay for experimental work with the following analysis:

pH	-	1.50
TDS	-	30,000 mg/l
SS	-	1000 "
Na_2SO_4	-	15,500 mg/l
$ZnSO_4$	-	250 "
H_2SO_4	-	3250 "

Initial experiments were carried out in test RO loop with an effective area membrane surface of 41 cm^2 supported on porous stainless steel (Fig.1) for the evaluation of membrane performance, with respect to feed pH, solute concentration, and flow velocity on permeate flux rate, solute rejection, concentration ratio, and permeate recovery at different pressures ranging from 25 to 60 kg/cm^2.

Further experiments were carried out on a tubular RO set-up (active membrane surface area of 2450 cm^2) at the DEED Lab of the Bhava Atomic Research Centre (BARC), Bombay, with three different types of membranes, i) Cellulose

Diacetate(CDA) from BARC , ii) CDA from CSMCRI, Bhavnagar, India, and iii) Thin film composite aromatic polyamide (PA-300) from UCP, USA.

Based on experimental data obtained with test RO loops(flat and tubular), a spiral wound RO module (capacity= I.50 lit permeate/min) was designed, fabricated(in collaboration with Permionics, Baroda, India), and standardized at the Chemical Engineering Department, IIT, Bombay.

Experimental flow-sheet diagram(connecting both the test loop and the spiral wound modules) is depicted in Fig.2.

As shown in Fig.2, pressure was regulated by a spring loaded SS back pressure regulating valve installed in the concentrate stream. Flow was controlled by adjusting the needle valves BVI and BV2. The system, at start-up, was slowly pressurized, and depressurized at shut-down, by operating the needle valves BV2 on the by-pass line. The concentrate and the permeate were recycled back into the IOO litre capacity HDPE feed tank, during experimental run.

A triplex plunger Pump (PT 8I/60 manufactured by the Speck of W.Germany) having rated capacity of I5 lit/min at discharge pressure of I20 kg/cm^2 was used.

A conductivity meter , calibrated against the range of compositions expected, was used to measure the stream concentrations in terms of TDS.

Conceptual design features of the spiral wound RO module is depicted in Fig.3, and the details presented as follows :

Size of the module	- 8.30 cm Ø X 60 cm length
Active membrane area	- 2.80 m^2
No. of membrane leaves	- 2

Dimensions of membrane leaves

= 55 cm width X I50 cm length.

Module is housed in IO cm diameter 40 schedule seamless M.S pipe of 60 cm length.

Membrane components:

Membrane	- CDA
Mem. support sheet	- woven polyester cloth
Permeate channel	- melamine formaldehyde impregnated polyester.
Concentrate channel	- 200 mesh HDPE net I.I2 cm thick.
Module wrap	- PVC tape
Product(permeate) tube	- PVC I.25cm tube diameter.

RESULTS AND DISCUSSIONS

Fig.4 represents flux decline results with untreated effluents (without pH adjustment) using CSMCRI membrane, which indicates pronounced flux decline due to fouling effects. Permeate flux and solute rejection % is found to be higher when feed pH is increased above 3.

Therefore, further investigations were carried out with pH adjustment to 4.80 followed by cartridge filtration whereby all suspended solids more than 5 μ could be removed from the feed. Feed pH could not be kept above 4.80 because of Zinc precipitation.

Experimental results depicted in Fig.5 indicates, that, permeate flux rate is above 0.60 $m^3/m^2/d$ (I5 gfd) and solute rejections (Na_2SO_4 and $ZnSO_4$) are higher than 97 % over the pressure range 40 - 60 kg/cm^2, PA-300 membrane providing best performance.

Zinc rejection is found to be above 99% with less than 4ppm appearing in the permeate at 60 kg/cm^2.

As presented in Fig.6, permeate flux rate, and solute rejections are adversely affected at higher level of permeate recovery.

When RO module is operated at above 60 kg/cm^2 pressure under minimum permeate recovery conditions, permeate quality is found to be below 200 ppm(with Zn^{++}content less than 4 ppm (Fig.7), which could be recycled back to the spinning process washing.

Na_2SO_4 concentration in the concentrate could be reached to the level of I6% under optimal conditions of RO treatment, and therefore complete recycling of permeate and concentrate streams appears to be technically feasible, according to the flow sheets presented in Fig. 8a, and 8b.

Reclamation of salts (Na_2SO_4 and $ZnSO_4$) and reusable water from spinning process wash effluents, along with abatement of pollution problems by RO technology,is expected to give considerable amount of socio-economic benefit to Rayon industries.

Further Work is in progress to evaluate long range membrane performance data at elevated temperatures in a spiral wound I5 lit/min RO plant (pilot unit), to confirm the operational data presented in this Work.

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