CONTENTS

	Title page	i
	Certificate of Approval	iii
	Certificate by the Supervisor	v
	Acknowledgement	vi
	Nomenclature	vii
	List of Figures	ix
	List of Tables	xiii
	Abstract	xv
	Contents	xvii
Chapter 1	**INTRODUCTION**	**1**
	1.1 INTRODUCTION TO MEMBRANES	1
	1.2 CLASSIFICATION OF MEMBRANES	2
	1.3 SOME IMPORTANT CONCEPTS RELEVANT TO MEMBRANE SEPARATION	3
	1.3.1 Feed	3
	1.3.2 Permeate	3
	1.3.3 Concentrate	3
	1.3.4 Flux	3
	1.3.5 Molecular Weight Cut Off (MWCO)	3
	1.3.6 Membrane Fouling	3
	1.3.7 Transmembrane Pressure	4
	1.3.8 Membrane Permeability	4
	1.3.9 Dead-End and Cross-Flow Filtration	4
	1.3.10 Concentration Polarization	5
	1.3.11 Solution – diffusion mechanism	6
	1.3.12 Darcy's law	6
	1.3.13 Stagnant film theory	6
	1.3.14 Kedem-katchalsky equation	6
	1.3.15 Types of motion through membranes	7
	1.3.15.1 Permeation	7
	1.3.15.2 Knudsen diffusion	7
	1.3.15.3 Convection	7

Copyright IIT Kharagpur

	1.4 ADVANTAGE OF MEMBRANE SEPARATION PROCESSES	7
	1.5 APPLICATION OF MEMBRANE SEPARATION PROCESSES	8
	1.6 MAJOR LIMITATIONS OF MEMBRANE SEPARATION PROCESSES	8
	1.6.1 Concentration Polarization	8
	1.6.2 Irreversible Membrane Fouling	9
	1.7 WAYS TO REDUCE CONCENTRATION POLARIZATION	10
	1.7.1 Change of Hydrodynamic Conditions	10
	1.7.2 Turbulent Flow	11
	1.7.3 Unsteady Flows and Induction of Instabilities	11
	1.7.3.1 Turbulence promoter	11
	1.7.3.2 Gas sparging	12
	1.7.3.3 Pulsatile flow	12
	1.7.4 Plasma Treatment	13
	1.8 TANNERY-MAJOR SOURCE OF POLLUTION	13
	1.9 CONVENTIONAL TREATMENT METHODS FOR THE TREATMENT OF TANNERY EFFLUENTS	15
	1.10 ADVANCED TREATMENT OF TANNERY EFFLUENT USING MEMBRANE PROCESSES	16
	1.11 SPECIFIC MEMBRANE PROCESSES FOR THE TREATMENT OF TANNERY EFFLUENT	17
	1.12 FACTORS AFFECTING MEMBRANE PERFORMANCE	18
	1.13 BACKGROUND OF PROPOSED RESEARCH	21
	1.14 OBJECTIVE OF THE WORK	22
	1.15 ORGANIZATION OF THE THESIS	23
Chapter 2	**TREATMENT OF PICKLING EFFLUENT**	**27**
	2.1 INTRODUCTION	27
	2.2 EXPERIMENTAL	28
	2.2.1 Effluent	28
	2.2.2 Chemicals used for Pretreatment	29
	2.2.3 Pretreatment	29
	2.2.4 Different molecular weight cut off membranes	29
	2.2.5 Dead-end filtration	31
	2.2.5.1 Procedure	31
	2.2.6 Cross Flow Ultrafiltration of Pickling Effluent	35

Copyright IIT Kharagpur

	2.2.6.1 Membranes	35
	2.2.6.2 Membrane filtration cell	35
	2.2.6.3 Experimental design	37
	2.2.6.4 Experimental procedure	37
	2.2.6.5 Analysis	38
	2.3 THEORY	39
	2.3.1 Numerical Solution	41
	2.4 RESULTS AND DISCUSSION	43
	2.4.1 Pretreatment	43
	2.4.2 Conduction of Ultrafiltration Experiments in Cross Flow Mode	43
	2.4.3 Model Parameters	45
	2.5 CONCLUSION	53
Chapter 3	**TREATMENT OF DEGREASING EFFLUENT**	**55**
	3.1 INTRODUCTION	55
	3.2 EXPERIMENTAL	56
	3.2.1 Effluent	56
	3.2.2 Chemicals Used	56
	3.2.3 Pretreatment	56
	3.2.4 Stirred Batch Cell Experiments	58
	3.2.5 Nanofiltration of Degreasing Effluent	61
	3.2.5.1 Membranes	61
	3.2.5.2 Membrane filtration cell	61
	3.2.5.3 Experimental design	61
	3.2.5.4 Experimental procedure	62
	3.2.5.5 Analysis	62
	3.3 THEORY	63
	3.3.1 Numerical Solution	64
	3.4 RESULTS AND DISCUSSION	66
	3.4.1 Pretreatment	66
	3.4.2 Nanofiltration of the Effluent	66
	3.5 CONCLUSION	73
Chapter 4	**TREATMENT OF FATLIQUORING EFFLUENT**	**75**
	4.1 INTRODUCTION	75
	4.2 EXPERIMENTAL	76
	4.2.1 Effluent	76

Copyright IIT Kharagpur

	4.2.2 Chemicals Used	77
	4.2.3 Pretreatment	77
	4.2.4 Stirred Batch Cell Experiments	78
	4.2.4.1 Transient Permeate Flux Profiles	79
	4.2.5 Nanofiltration and Reverse Osmosis of Fatliquoring Effluent	81
	4.2.5.1 Membranes	81
	4.2.5.2 Membrane filtration cell	81
	4.2.5.3 Experimental design	81
	4.2.5.4 Experimental procedure	82
	4.2.5.5 Analysis	82
	4.3 THEORY	83
	4.4 RESULTS AND DISCUSSION	83
	4.4.1 Pretreatment	83
	4.4.2 Nanofiltration of the Effluent	85
	4.4.3 Reverse osmosis of the Effluent	93
	4.5 CONCLUSION	100
Chapter 5	**USE OF AIR SPARGING AND PLASMA TREATMENT FOR FLUX ENHANCEMENT**	**101**
Part 1	FLUX ENHANCEMENT USING AIR SPARGING DURING MEMBRANE SEPARATION OF PECTIN AND DEGREASING EFFLUENT	102
	5.1 INTRODUCTION	102
	5.2 EXPERIMENTAL	103
	5.2.1 Materials	103
	5.2.2 Membrane Cell with Air Sparging Set-Up	104
	5.2.3 Experimental Design	105
	5.2.4 Experimental Procedure	105
	5.2.5 Optical Measurement of Deposition Thickness	106
	5.3 RESULTS AND DISCUSSION	107
	5.3.1 Effect of Gas Flow Rate on Permeate Flux and Deposition Thickness	107
	5.3.2 Variation of Permeate Flux and Deposition Thickness with Different Membrane Orientations	108
	5.3.3 Effect of Permeate Flux and Deposition Thickness with Transmembrane Pressure Drop	110
	5.3.4 Variation of Deposition Thickness and Permeate Flux with Concentration and Cross Flow Velocity	112

Copyright IIT Kharagpur

	5.3.5 Flux Enhancement during Ultrafiltration of Pectin	113
	5.3.6 Airsparging during Nanofiltration of Tannery Effluent	113
	5.4 CONCLUSION	116
Part 2	FLUX ENHANCEMENT BY ARGON – OXYGEN PLASMA TREATMENT OF MEMBRANES	117
	5.5 INTRODUCTION	117
	5.6 EXPERIMENTAL	118
	5.6.1 Materials	118
	5.6.2 Surface Modification of Membranes by Ar-O2 Plasma Treatment	118
	5.6.3 Characterization of Membrane Surface	118
	5.6.3.1 Contact angle measurement	118
	5.6.3.2 Permeability measurement and ultrafiltration of PEG (20,000)	120
	5.6.3.3 SEM analysis of the untreated and treated membranes	120
	5.6.3.4 Evaluation of deposition thickness	120
	5.6.3.5 FTIR	122
	5.7 RESULTS AND DISCUSSION	122
	5.7.1 Hydrophilicity Enhancement by Plasma Treatment	123
	5.7.2 Permeability	126
	5.7.3 Increase in Pore Area	126
	5.7.4 Separation of PEG (20,000) Solution	128
	5.7.5 Quantification of Solute Deposition	128
	5.8 CONCLUSION	131
Chapter 6	**CONCLUSION AND FUTURE WORK**	**133**
	REFERENCE	**137**
	Curriculum Vitae	149
	Contributions Made by the Scholar	151

Copyright IIT Kharagpur