OSM CO.

MEMBRANE CHEMICALS

Presented by: Majid Karami

OSM CO.

Introduction

★ Water shortage is becoming a worldwide problem

★ One of the main solutions to this problem is : Desalination of seawater or brackish water

★ Desalination of seawater accounts for a worldwide water production of 24.5 million m3/day and Iran’s share is about 505,000 m3/day (2009)

★ Increasing the cost of transferring water and dec[illegible]g the desalination cost, has caused this technology t[illegible] more popular

OSM CO.

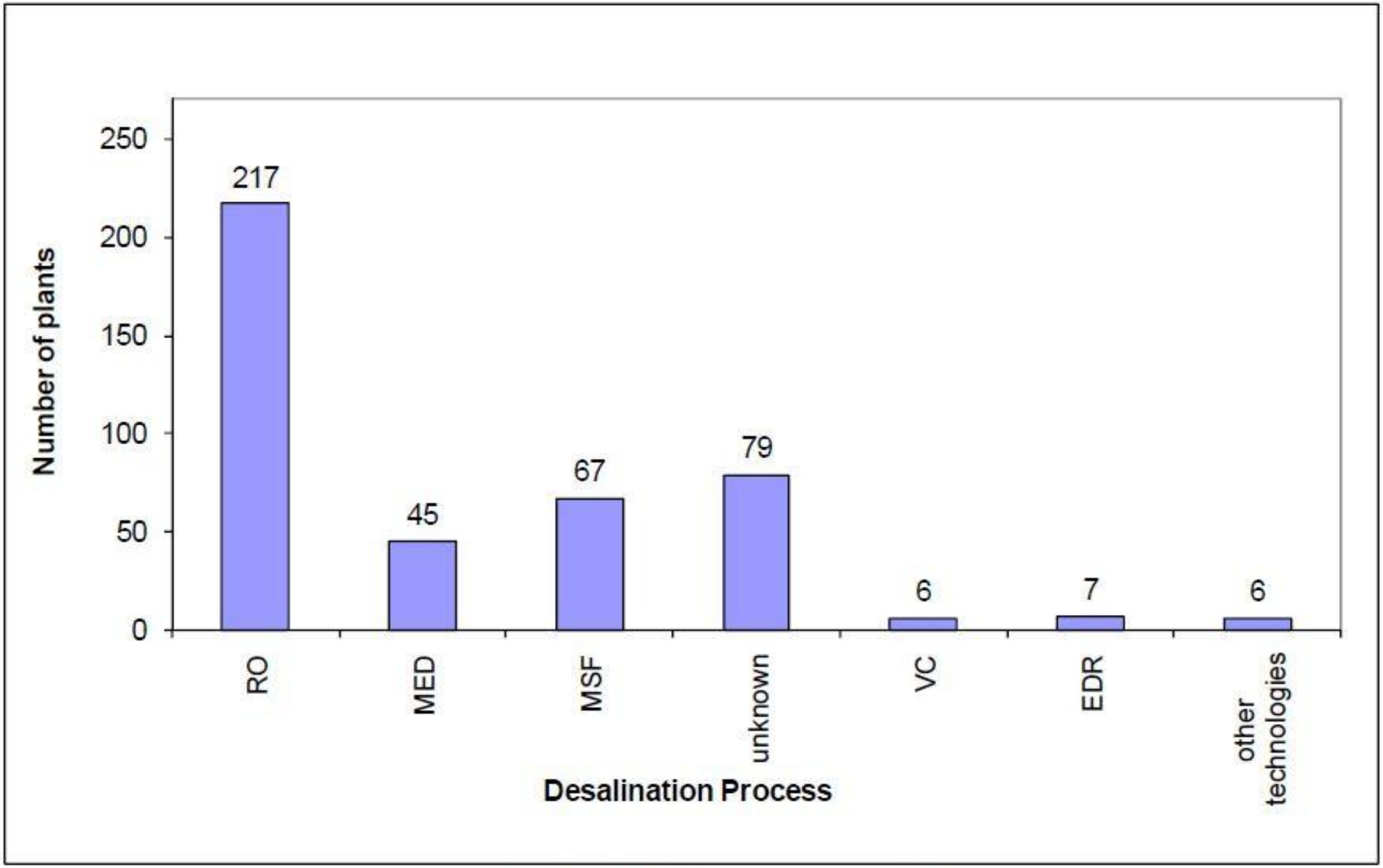


Figure 1. Desalination processes in Iran

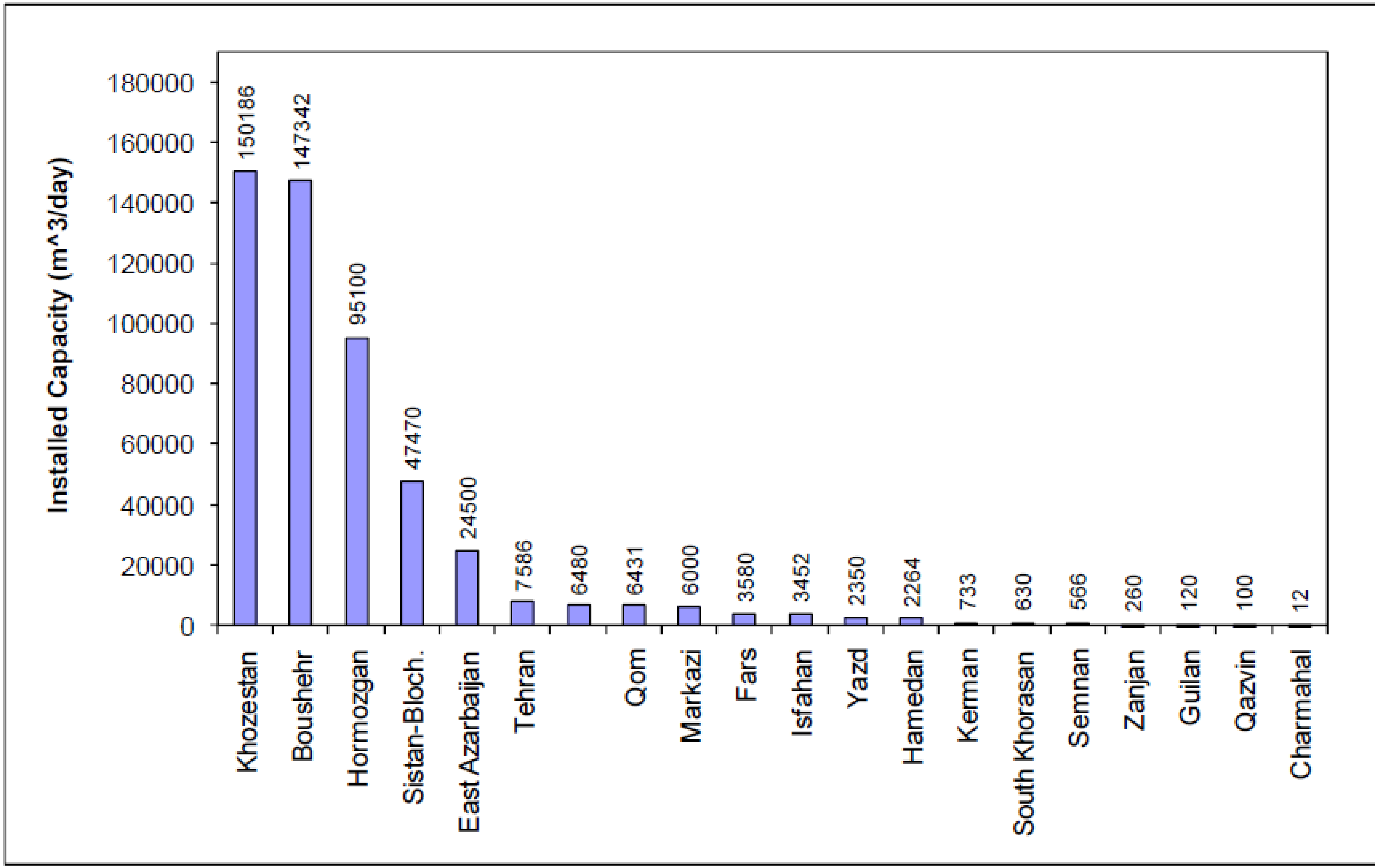


Figure 2. Installed capacity in Iran's provinces

Introduction

Desalination technology like any other technology has some issues and problems such as:

★ Fouling
★ Scaling
★ Corrosion

Which causes:

★ A decrease in operational efficiency
★ Negative effects on the environment
★ Higher cost of water production in some areas

OSM CO.

Fouling & Scaling

Fouling includes the accumulation of all kinds of layers on the membrane and feed spacer surface, including scaling, such as:

★ Inorganic colloids: iron flocs, silica, clay, silt

★ Organic colloids: oil, organic polymers, microorganisms

Scaling will refer to the precipitation and desorption within the system of sparingly soluble salts such as:

★ Calcium carbonate, barium sulfate, calcium sulfate, strontium sulfate, and calcium fluoride

OSM CO.

Pretreatment Options

Pretreatment	$CaCO_3$	$CaSO_4$	$BaSO_4$	$SrSO_4$	CaF_2	SiO_2	SDI	Fe	Al	Bacteria	Oxid. agents	Org. matter
Acid addition	●							○				
Scale inhibitor antifoulant	○	●	●	●	●	○		○				
Softening with IX	●	●	●	●	●							
Dealkalization with IX	○	○	○	○	○							
Lime softening	○	○	○	○	○	○	○	○				○
Preventive cleaning	○					○	○	○	○	○		○
Adjustment of operation parameter	○	○	○	○	○	●						
Media filtration						○	○	○	○			
Oxidation filtration							○	●				
In-line coagulation							○	○	○			○
Coagulation-flocculation						○	●	○	○			●
Microfiltration/Ultrafiltration						●	●	○	○	○		●
Cartridge filtration						○	○	○	○	○		
Chlorination										●		
Dechlorination											●	
Shock treatment										○		
Preventive biocidal treatment										○		
GAC filtration										○	●	●

○ Possible ● Very effective

OSM CO.

Cleaning Chemicals

Foulant \ Cleaner	0.1 wt % NaOH	0.1 wt % NaOH with 1.0 wt % Na_4EDTA	0.1 wt % NaOH with 0.025 wt % Na-DDS	0.2 wt % HCl	2% citric acid	1.0 wt % $Na_2S_2O_4$	0.5 wt % H_3PO_4	1.0 wt % NH_2SO_3H
Carbonate scales (e.g., $CaCO_3$)		—	—	Preferred	Alternative	Optimal	Alternative	—
Sulfate scales ($CaSO_4$, $BaSO_4$)		OK	—	—		—	—	—
Metal/oxides hydroxides (e.g., iron)		—	—	—	Alternative	Preferred	Alternative	Alternative
Fluoride scales		OK						
Phosphate scales				Preferred				
Inorganic colloids (silt)		—	Preferred	—		—	—	—
Silica	Alternative	Alternative	Preferred	—		—	—	—
Biofilms	Preferred	Alternative	Preferred	—		—	—	—
Organic	Preferred	Alternative	Preferred	—		—	—	—

Scale Control Methods

(1) Acid Addition:

★ Effective in preventing the precipitation of $CaCO_3$

★ Ineffective in preventing other types of scale such as $CaSO_4$

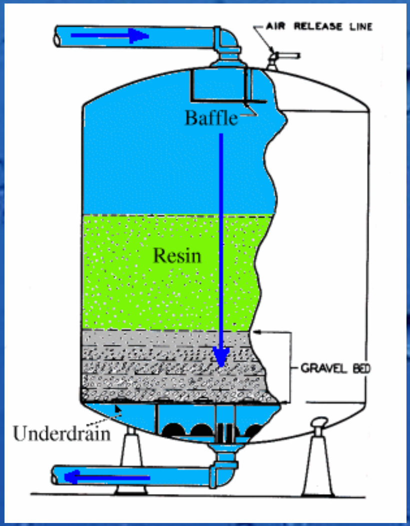
★ Corrosivity of the acid

(2) Softening:

★ The main disadvantage of softening is cost ($)

$$Ca^{+2} + 2NaZ \rightarrow 2Na^{+} + CaZ_2$$

$$Mg^{+2} + 2NaZ \rightarrow 2Na^{+} + MgZ_2$$



(3) Antiscalant Addition

OSM CO.

Antiscalant Addition

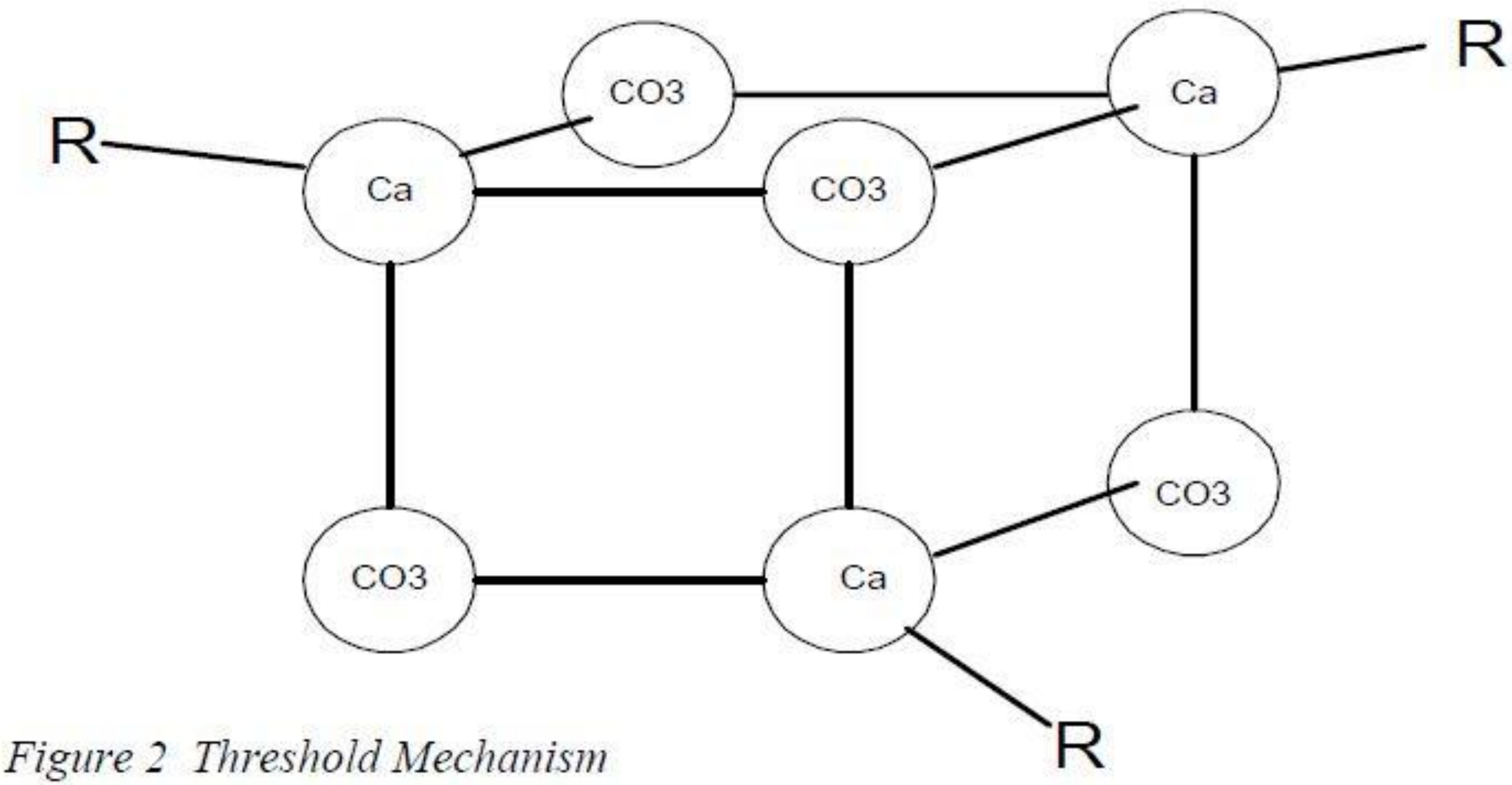


Figure 2 Threshold Mechanism

Antiscalant Addition

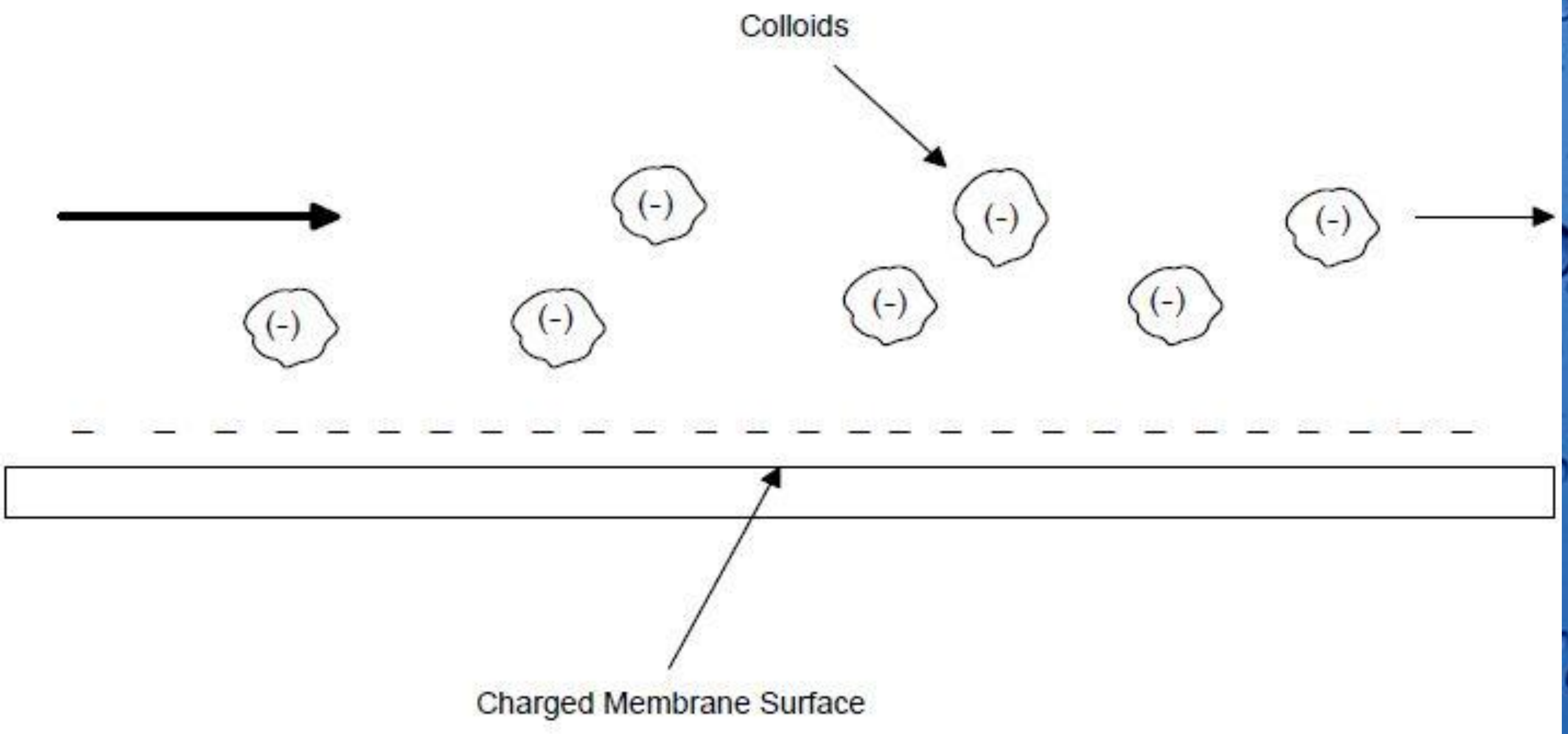


Figure 3 Dispersancy

Antiscalant Addition

DEQUEST®	$CaCO_3$	$CaSO_4$	$BaSO_4$	$CaPO_4$	CaF_2	$SrSO_4$	Silica	Metal Oxides
SPE 0001	✓	●		●	✓			●
SPE 0106	✓	✓			✓			●
SPE 0107	✓	●	●	●	✓	●	●	✓
SPE 0108	●		✓	✓	●	✓	✓	✓
SPE 0109		●	✓	✓		✓	✓	✓
SPE 0109 POT		●	✓	✓		✓	✓	✓
SPE 0111	✓	●		●	✓			●
SPE 0112	✓	●		●	✓			●
SPE 0125	✓	●		●	✓			●

✓ Best efficacy

● Good efficacy

OSM CO.

Antiscalant Addition

Dosage rates depends to:
★ Water Analysis
★ Flow rate
★ Recovery
★ Water source
★ pH
★ Temperature
★ Membrane type & RO configuration
★ Typical dosage rates are 1-6 mg/lit

Recovery:
★ As the recovery rate increases the concentration of dissolved salts in the reject water stream increases and leading to salt precipitation and scale formation

OSM CO.

Antiscalant Addition

Dosage calculation:

$$\text{Dosage (ppm)} = \frac{V_1 \times S.G \times 1000}{Q \times V_2} \times \text{Dosing Rate}$$

V_1= volume of Antiscalant (Lit)

S.G= Specific Gravity of Antiscalant

Q= Feed Flow Rate (m^3/hr)

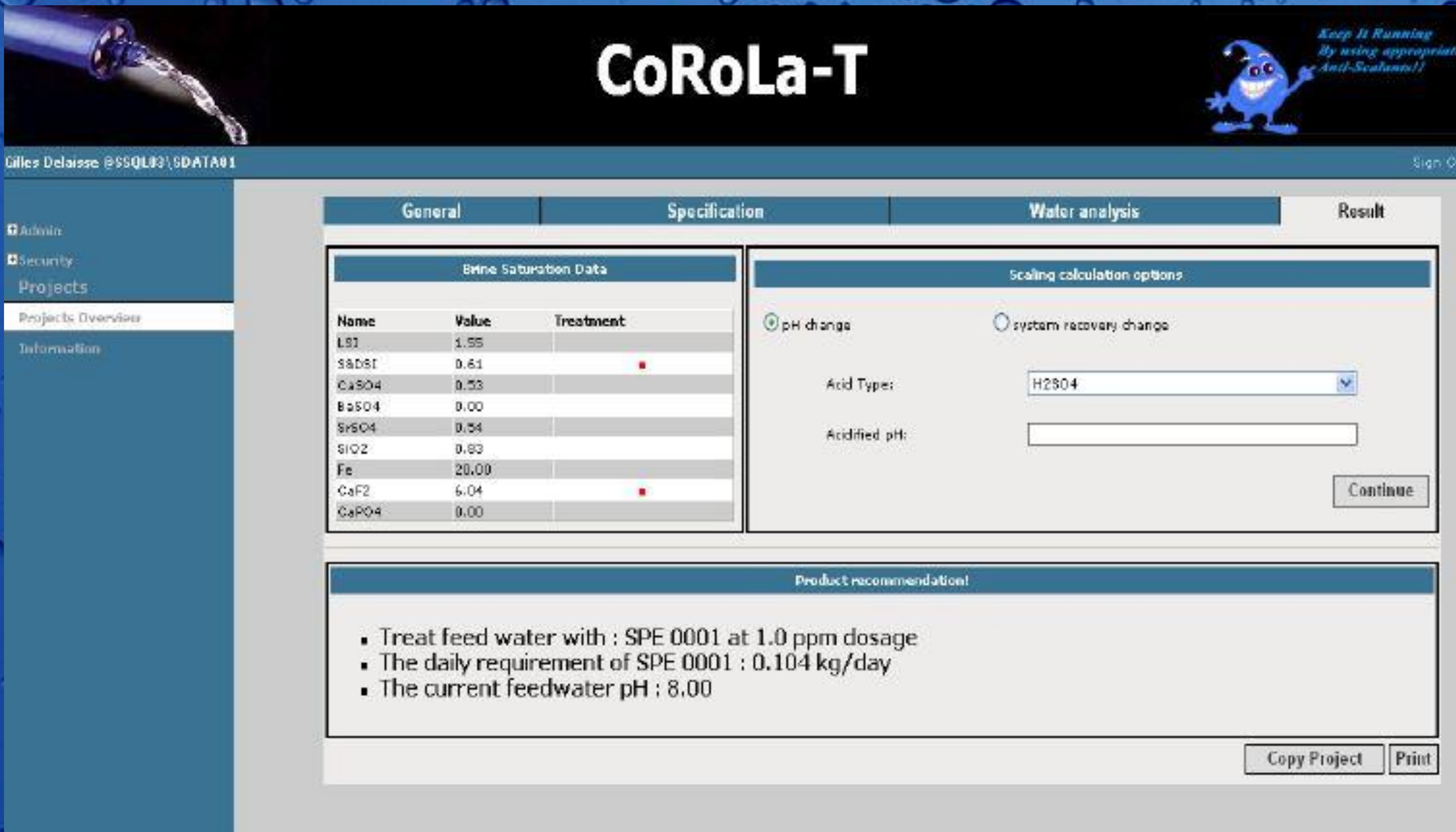
V_2= volume of water in dosing tank (Lit)

Dosing Rate (Lit/hr)

★ CoRoLa-T: software for selection of the most appropriate antiscalant for a specific system

OSM CO.

Antiscalant Addition



Case Study

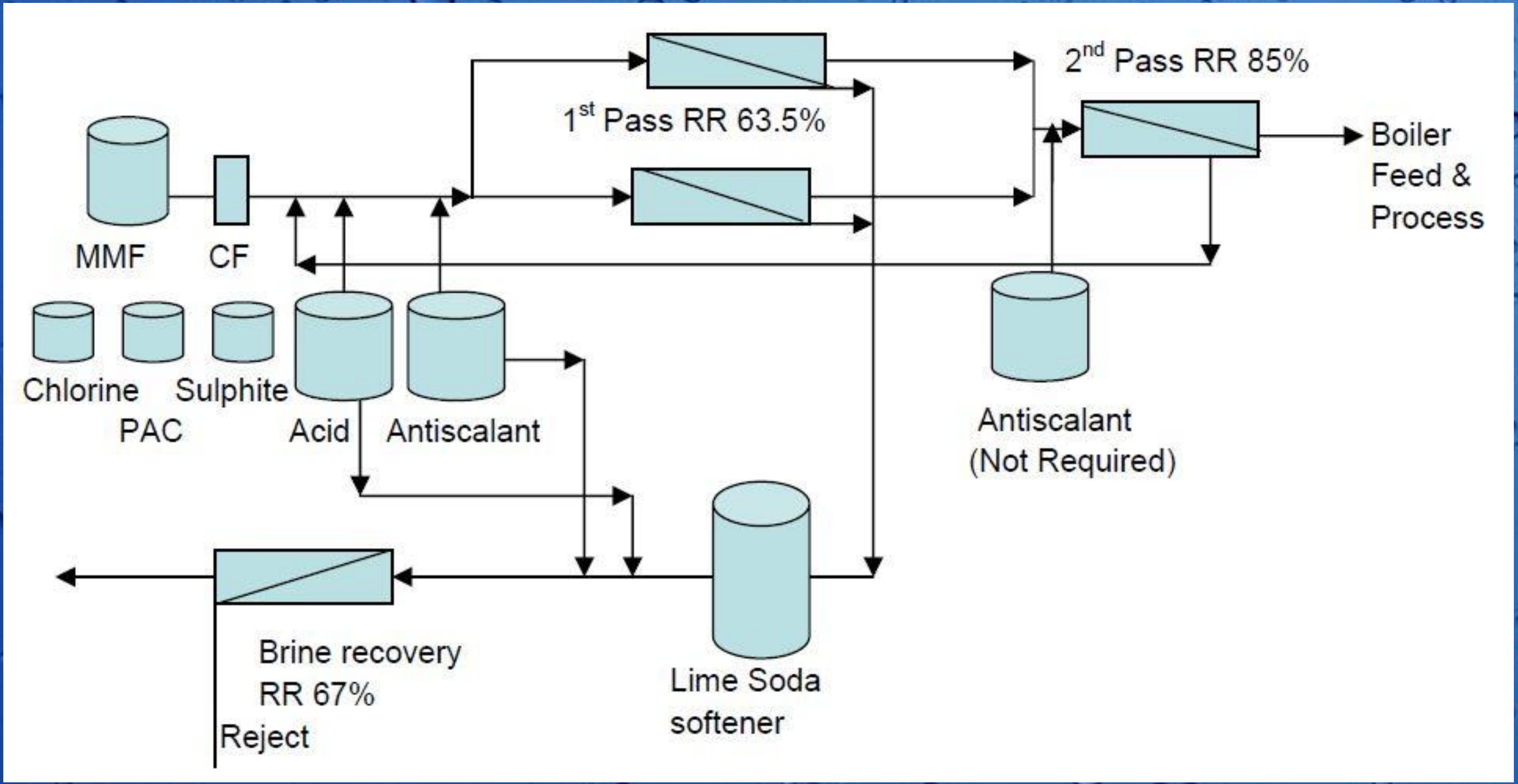
A chemical manufacturing company in Iran:

★ 7,000 m3/day two pass brackish water RO plant
★ With brine recovery RO (BRRO)
★ First pass with two identical skids (A & B)
★ Each skid is two stages in 20:10 array
★ Each pressure vessel having 6 membrane elements
★ Both skids (A & B) have a design permeate flow of 143 m3/hr at 63.5% recovery
★ Total first pass production of 286 m3/hr
★ Pretreatment for the first pass: aluminium salt coagulant, hydrochloric acid injection, chlorination, multi-media filtration, phosphonate based antiscalant injection, SMBS injection, cartridge filteration
★ Second pass is designed to operate at 85% recovery

OSM CO.

Case Study

Schematic of plant layout:



OSM CO.

Case Study

Description:

★ Raw water derives from underground wells

★ Chemical water analysis (as ions): calcium of 785 mg/l, sulphate at 2149 mg/l, bicarbonate of 141 mg/l, with pH 7.5 and TDS 4745 mg/l

★ Scaling prediction: calcium carbonate, calcium sulphate and barium sulphate salts all exceeded their solubility limits

★ Standard anttiscalant could inhibit calcium carbonate and barium sulphate but not calcium sulphate at these high values

Case Study

Problem:

★ The first pass trains A & B of the plant historically suffered from calcium sulphate deposition

★ Operators decided to reduce recovery rates to 48% against a design specification of 63.5%

★ Even at lower recovery rates the membranes fouled after 4 - 5 weeks of operation with feed pressure increasing from 10 to 12.5 bar

★ Cleaning was carried out when ΔP reached 6.5 bar by circulating a solution of Ethylene Diamine Tetra Acetic acid (EDTA) and Sodium TripolyPhosphate (STPP) at high pH

OSM CO.

Case Study

Recommendations:

★ In November 2007 the new calcium sulphate specific antiscalant was used and acid dosing was stopped

★ At 4.7 mg/l dosed to the feed water this approch has successfully prevented scale formation

★ The recovery rates were increased to 61%

★ The plant requiring only one membrane clean in 18 months instead of one every month as previously

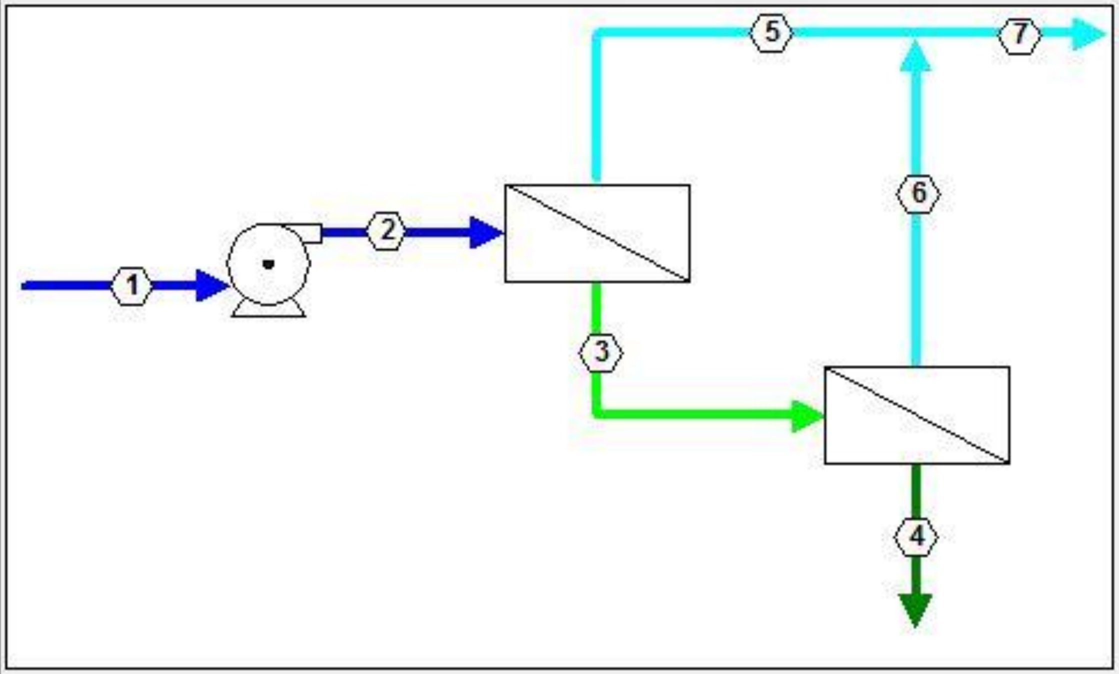
★ The second pass permeate polisher is operating without the need for antiscalant due to the good quality permeate from the first pass

OSM CO.

Case Study

Initial design with 63.5% recovery:

TWO STAGE SYSTEM



		1	2	3	4	5	6	7
Flow	m3/hr	225.2	225.2	113.7	82.2	111.6	31.5	143.0
Pressure	bar	0.0	11.3	10.4	9.0	0.0	0.0	0.0
TDS (ppm)		4715.6	4715.6	9308.0	12827.8	36.8	109.0	52.7

Case Study

Results and cost saving for Water:

	Permeate m^3/hr	Feed m^3/hr @ 48% Recovery	Feed m^3/hr @ 61% recovery	Feed Saving m^3/hr	Feed Saving $m^3/annum$
Skid A	143	298	234	64	560,640
Skid B	143	298	234	64	560,640
TOTAL	286	596	468	128	1,121,280

Case Study

Results and cost saving for Energy:

★ Initial design:

Feed pressure	bar	11.3
Concentrate pressure	bar	9.0
Permeate flow	m3/hr	143.0
Pump Feed Flow	m3/hr	225.2
Recovery ratio, %		63.5
Pump efficiency, %		83.0
Motor efficiency, %		93.0
Power/Stage/Pass, kw		89.8
Total Pumping power, kw		89.8
Pumping specific energy	kwhr/m3	0.64

Case Study

Results and cost saving for Energy:

Skid 1 a	**Nov-03 Design**	**Sep-07**	**Feb-08**	**Feb-09**
Feed Pressure Bar	12.80	12.50	10.70	12.00
% Recovery Rate	64	48	58	61
Feed Flow m3/hr	225.20	283.00	243.00	228.00
Permeate Flow m3/hr	143.00	136.00	140.00	139.00
Pump Energykwhr/m³	0.63	0.85	0.58	0.62
Energy KwHr	141.88	240.55	140.94	141.36
Total Energy/annum KwHr	1225808.64	2078352.00	1217721.60	1221350.40
Pumping Costs/ annum	$85,806.60	**$145,484.64**	$85,240.51	**$85,494.53**

Case Study

Conclusions:

	Sulphate Case Study
Water Saving, m^3/annum	1,121,280
Energy Saving, KwHr	857,002 (1 skid)
Energy Costs Saving, US$/annum	$60,000
Membrane Replacement, US$/annum	$39,000
Chemical saving, US$/annum	$37,000
Total, US$/annum	$136,000

OSM CO.

Case Study

Conclusions:

This Case Study demonstrates that the selection of the correct chemical programme and using species specific antiscalant can result in:

- ★ **Optimizing the recovery rate so as to minimize pumping costs**
- ★ **Maintaining membrane cleanliness and reducing cleaning frequency**
- ★ **Extending the lifespan of the membranes thereby reducing replacement costs**
- ★ **Removing the dependency and the cost of dosing large quantities of non specific commodity chemicals which frequently has a positive environmental impact**