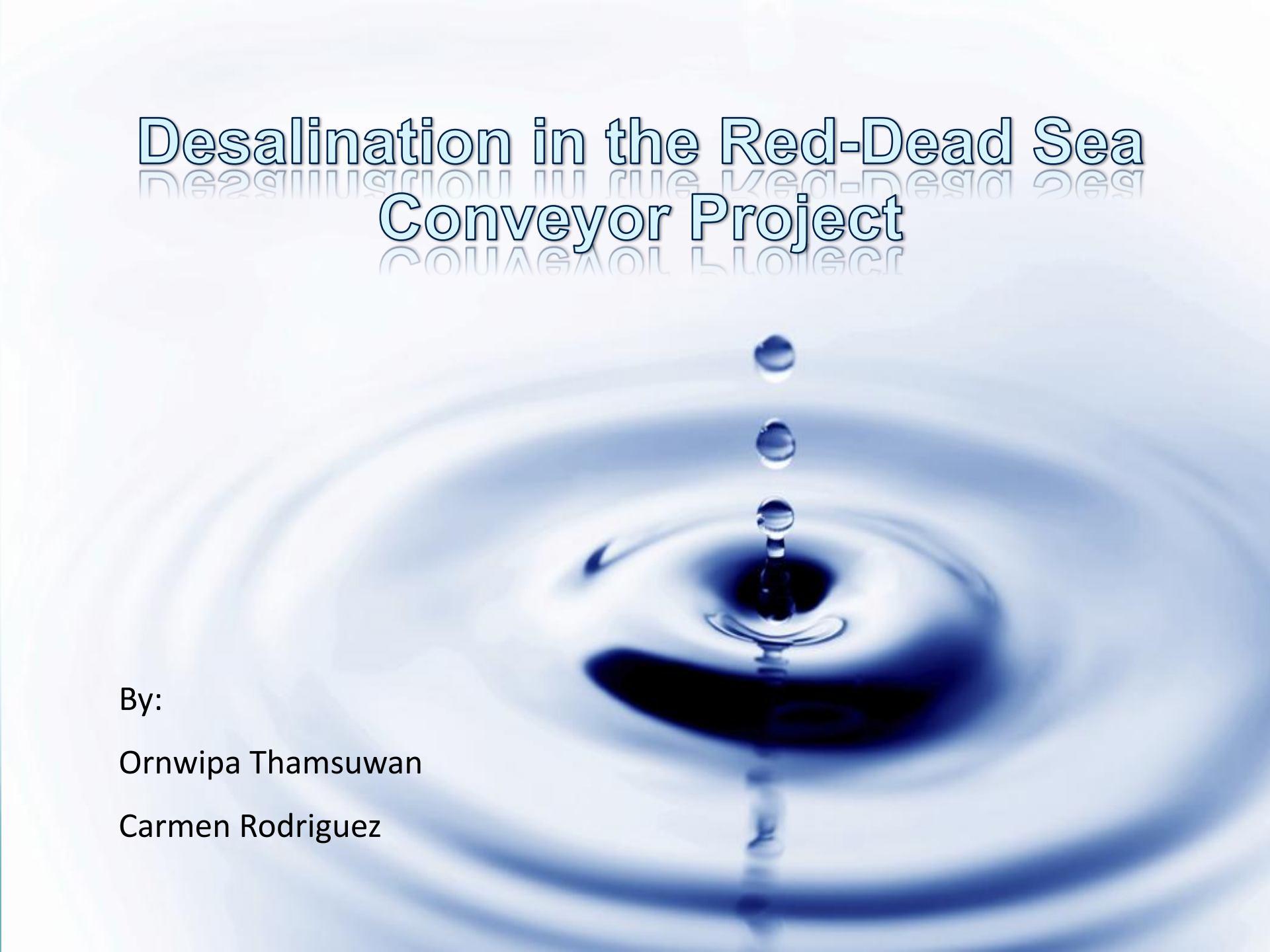
Desalination in the Red-Dead Sea Conveyor Project

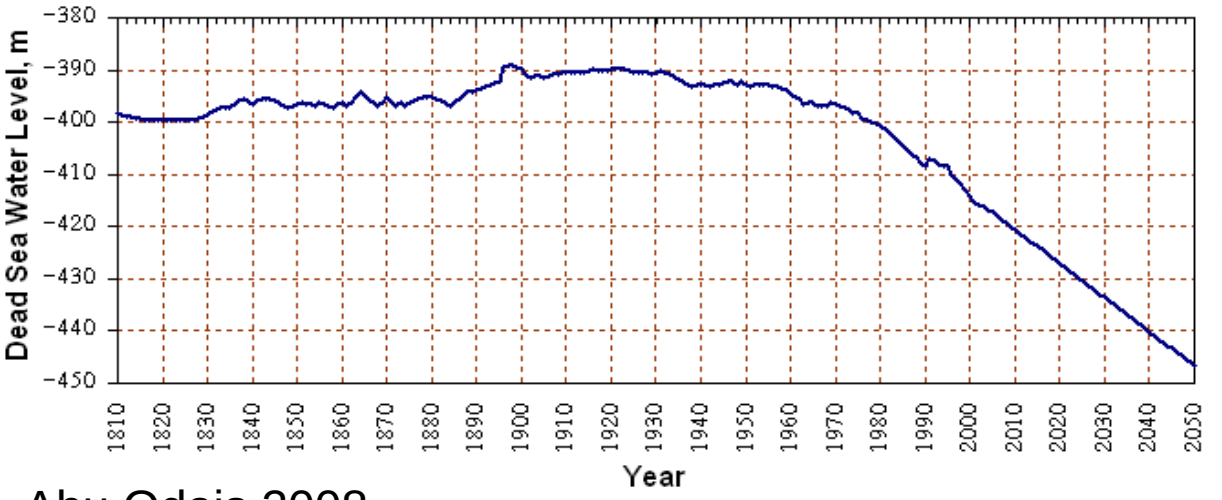


By:

Ornwipa Thamsuwan

Carmen Rodriguez

Declination of the Dead Sea

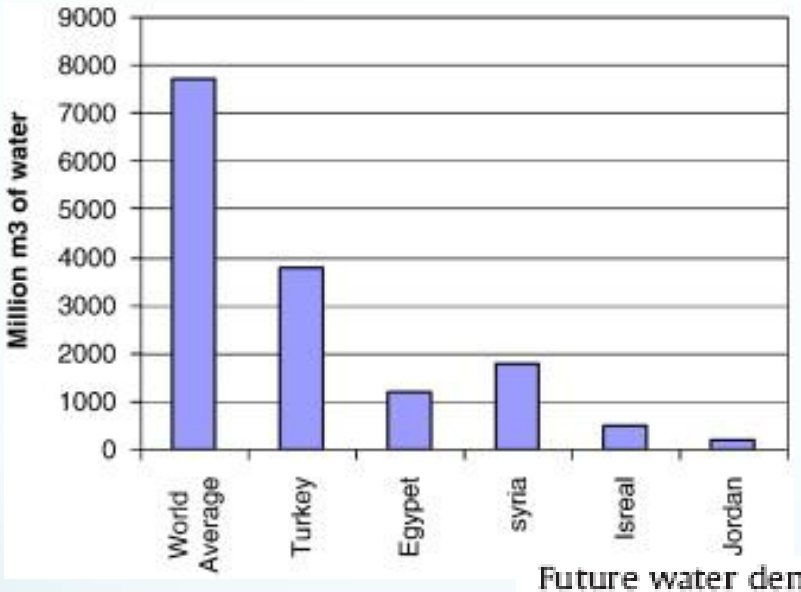


Abu Qdais 2008

Jordan is currently one of the ten water poorest countries in the world

Population versus per capita water availability.

Year	Total annual renewable fresh water available (Mm^3)	Population (millions)	Per capita water availability (m^3)
1955	1331	1.447	920
1990	906	4.009	226
2020	1236	10.229	120



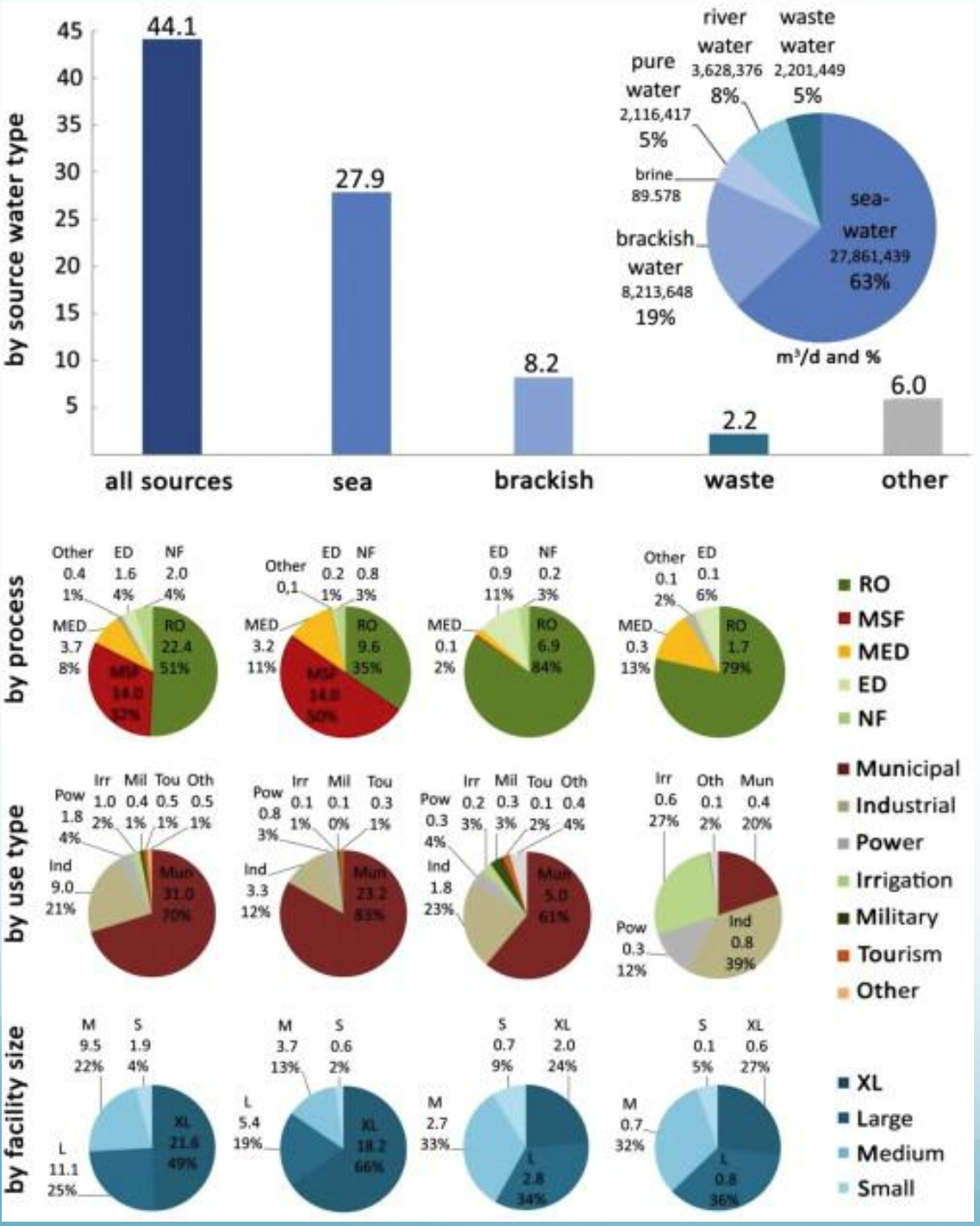
Hadadin et al. 2010

Water Authority Jordan 2005

Future water demand, supply and deficit in Jordan (Mm^3/yr).

	2010	2020	2040
Total water demand	1383	1602	2236
Domestic	477	670	1263
Industrial	110	130	170
Irrigation	796	802	803
Total water supply	1054	1152	1549
Surface water	470	470	470
Ground water	271	277	277
Water deficit total	−329	−451	−687

Global desalination capacities (Mm³/day and %)



RO, reverse osmosis
MSF, multistage flash distillation
MED, multieffect distillation
NF, nanofiltration
ED, electrodialysis

XL ≥ 50,000 m³/day > L ≥ 10,000 m³/day > M ≥ 1,000 m³/day > S

Lattermann et al. 2010

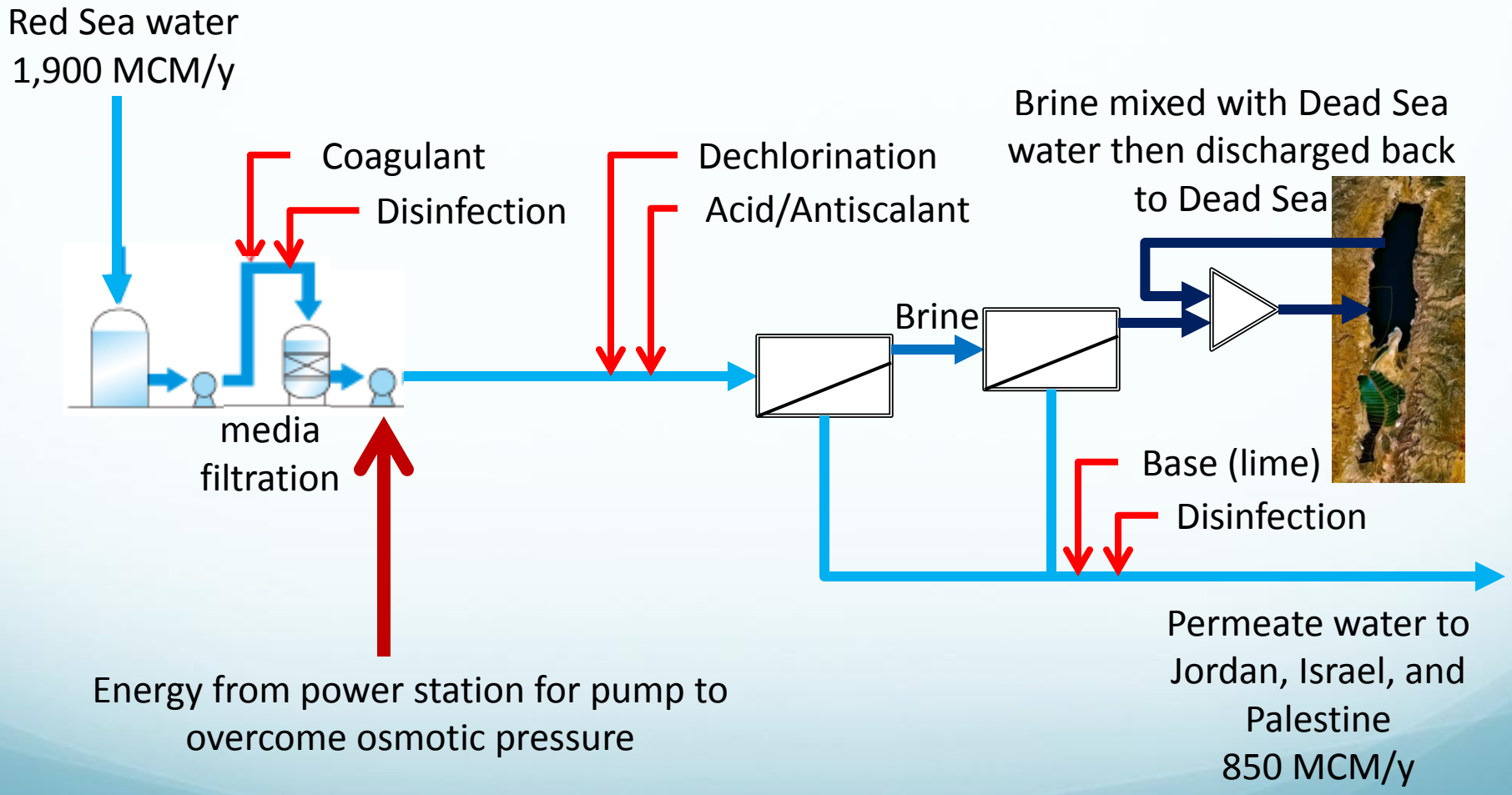
Red-Dead Sea Conveyor (RDSC) Project

- Phase 1: water transfer from Red Sea to Dead Sea
- Phase 2: hydropower generation and **reverse osmosis desalination facility**

  (capacity 850 MCM/year)
- Phase 3: freshwater transmission system

Abu Qdais 2008

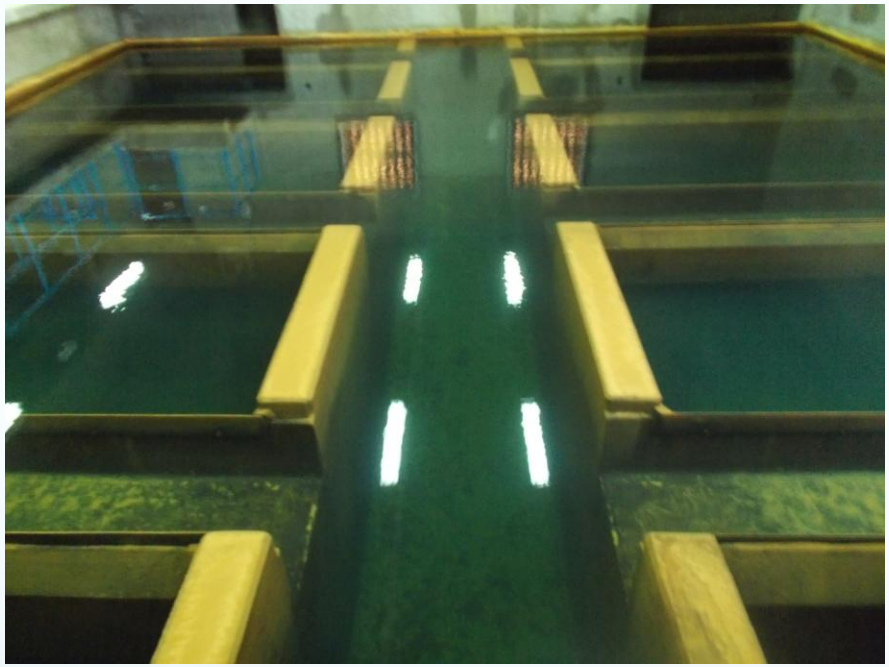
RDSC Desalination Process



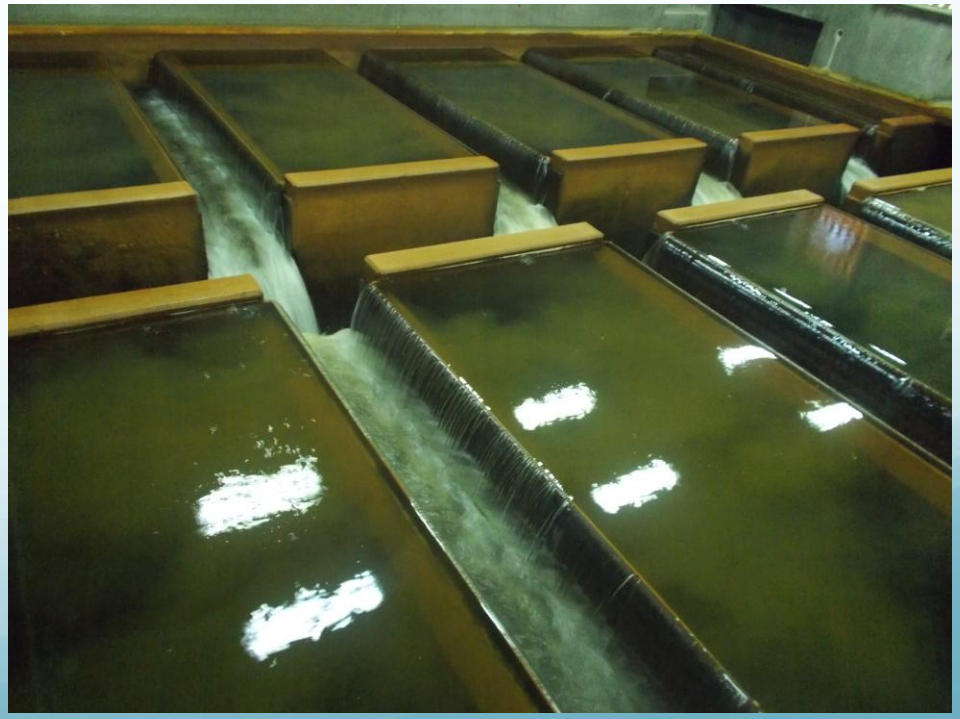
Pretreatment - Coagulant

- Add coagulant
- Particle Destabilization
- Process Time: ~10s

Pretreatment – Media Filtration

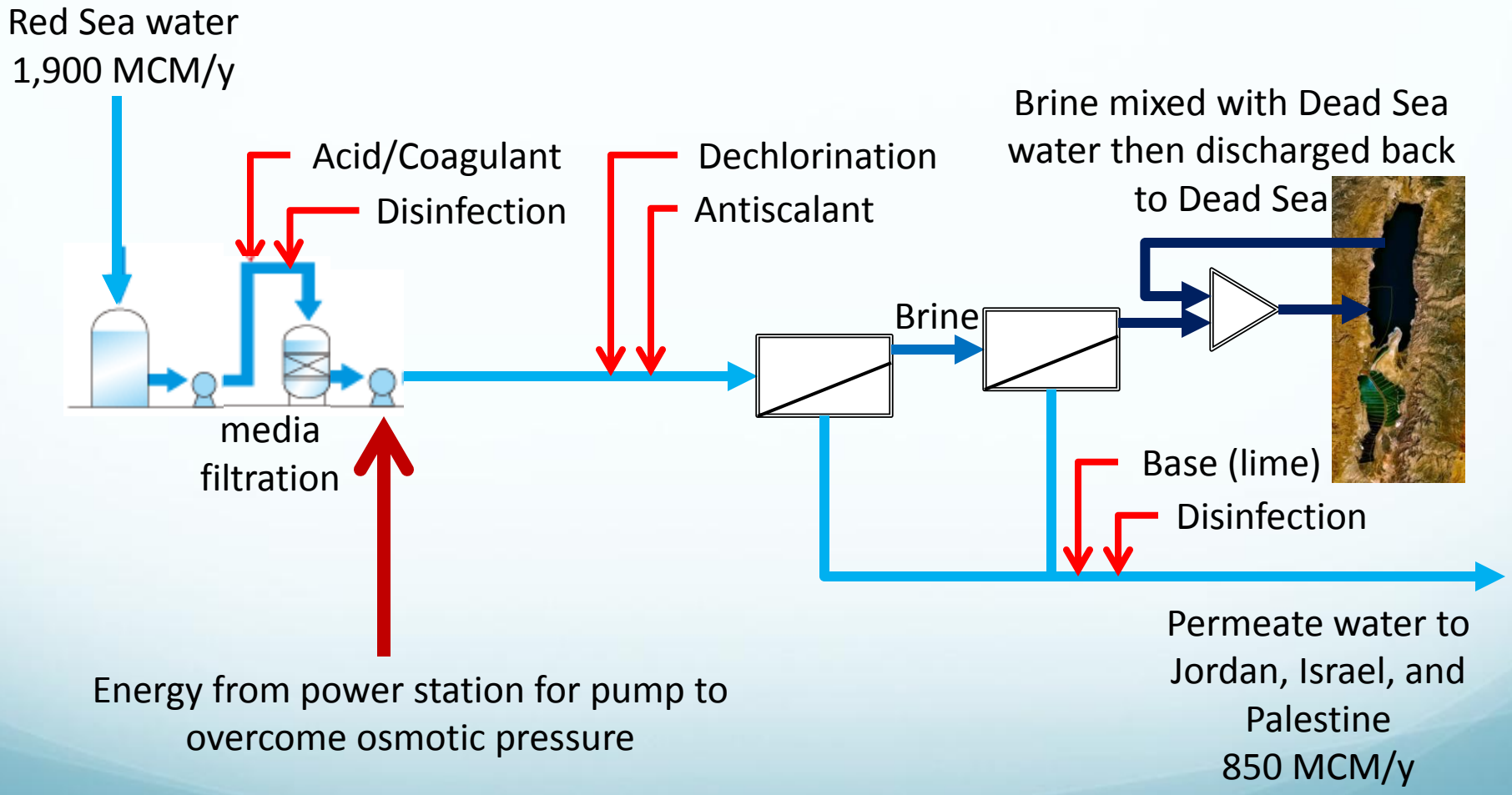


- Media:
  - Anthracite/Sand/Gravel

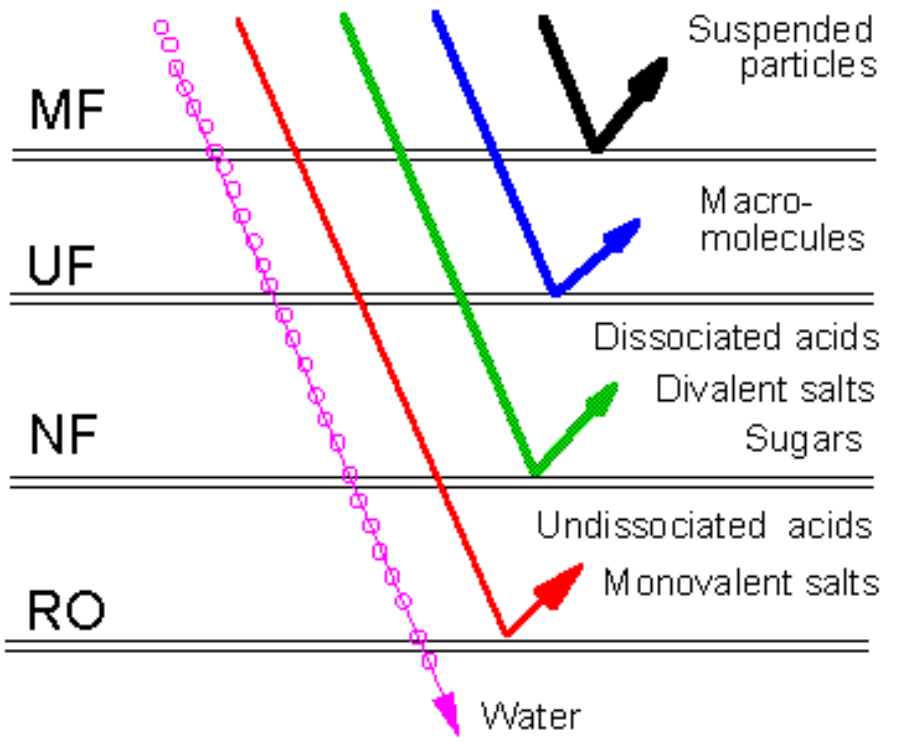


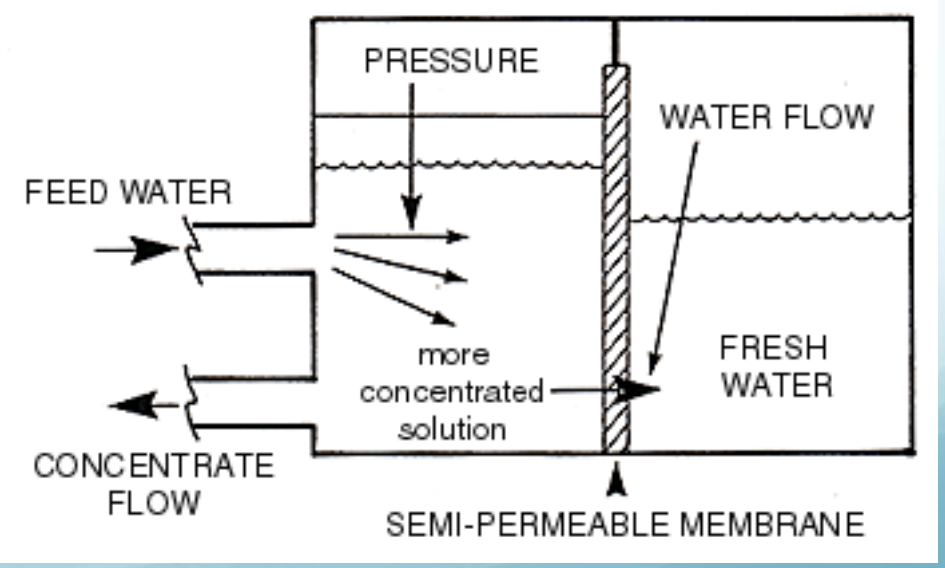
Backwash

RDSC Desalination Process



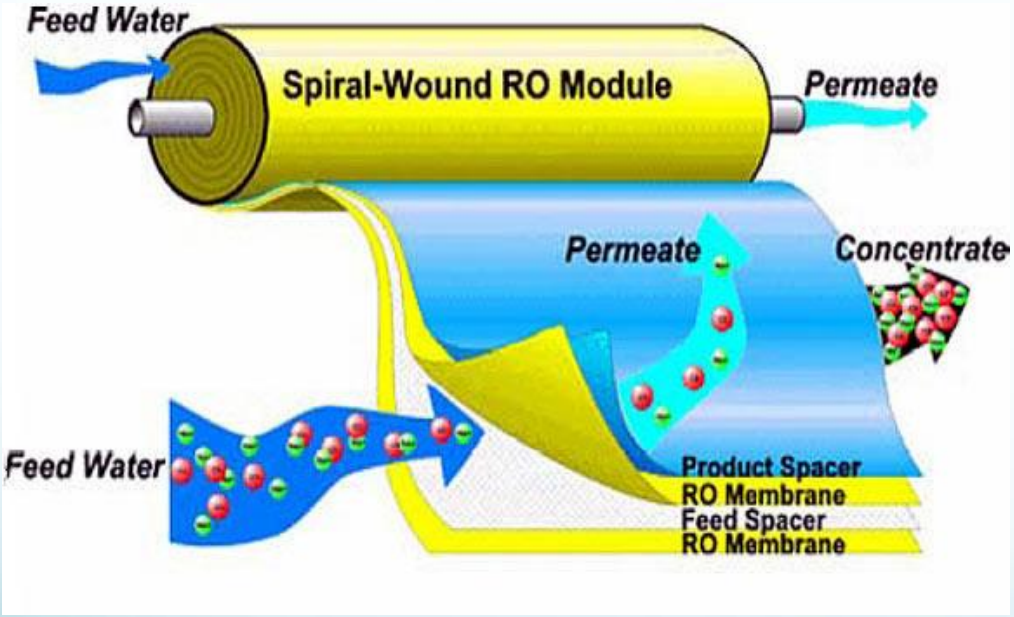
Reverse Osmosis (RO)





RO Membrane Configuration

- Spiral-wound modules



RO Membrane Material Selection

Cellulose Acetate (CA) V.S. Polyamide (PA)

CA	PA
Advantages - Tolerant to Chlorine < 1 mg/l	Advantages - Stable over pH = 3-11 - Tolerant to bacterial degradation - Produce higher flux
Disadvantages - Not tolerant to temperature > 30°C - Hydrolyze when pH > 8 or < 3	Disadvantages - Not tolerant to Chlorine

Osmotic Pressure Calculation

Red Sea Water (Abu Qdais and Batayneh 2002)

Parameter	Value
Temperature (°C)	22
pH	8.3
TDS (mg/l)	43,200

MW_{NaCl} = 58.6 g/mol

π = cRT

= [(2 moles)(43.2 g/l)(0.082 l.bar/K.mol)(295 K)]/(58.6 g/mol)

= 35.67 bar

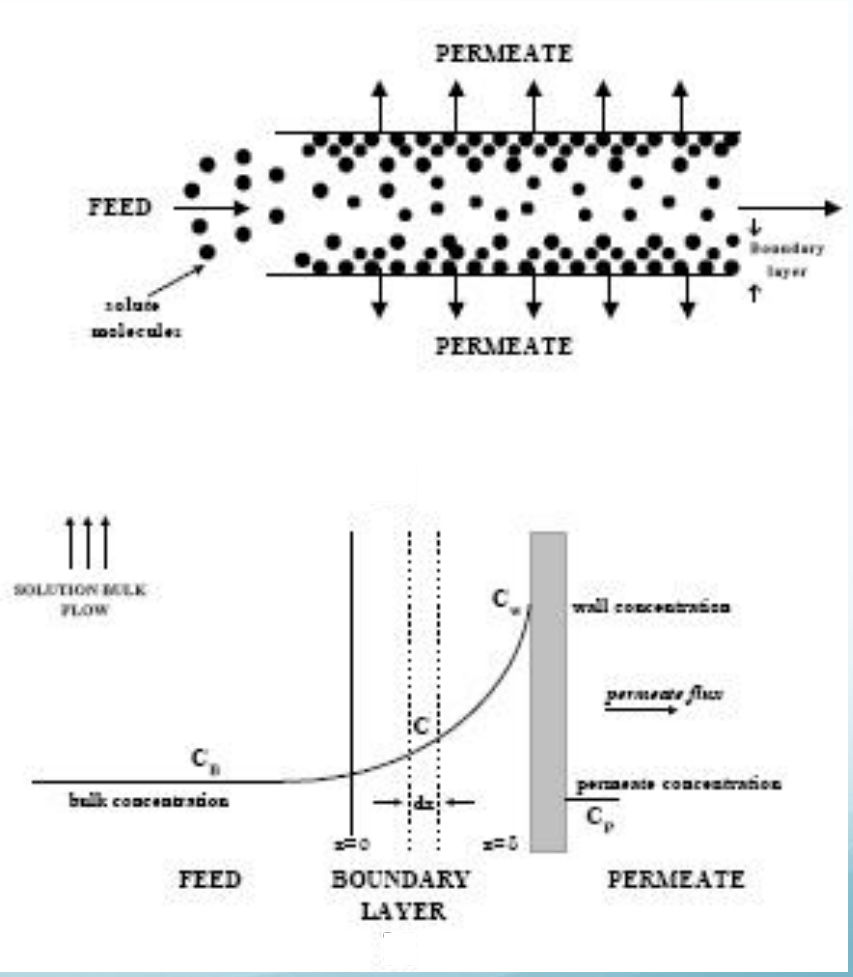
= 517.35 psi >> 14.696 psi

= 3,567 kPa >> 101.325 kPa

} Atmospheric pressure

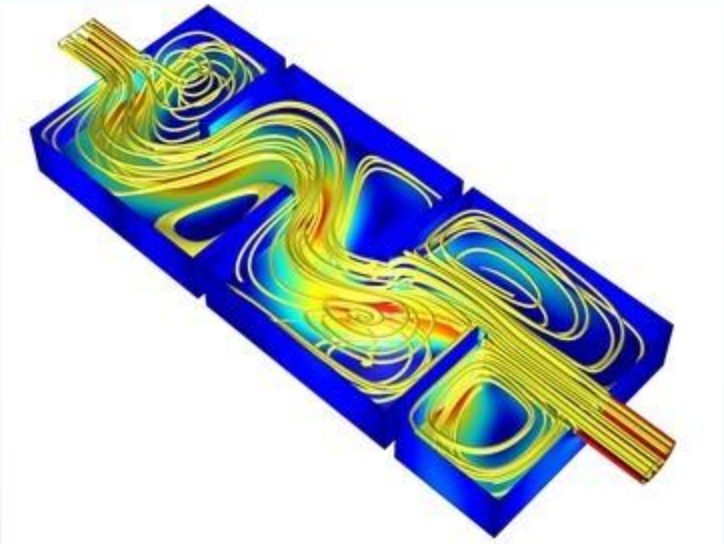
Major concern in RO process

- Concentration Polarization (CP) = formation of concentration boundary layer
  - If contaminant is dissolved, osmotic pressure increases.
  - If contaminant is particulate, frictional resistance to water flow increases.
- When CP reaches its critical value, second layer forms between CP and membrane
  - Discrete particles – cake
  - Colloids – gel
  - Molecules precipitated – scale



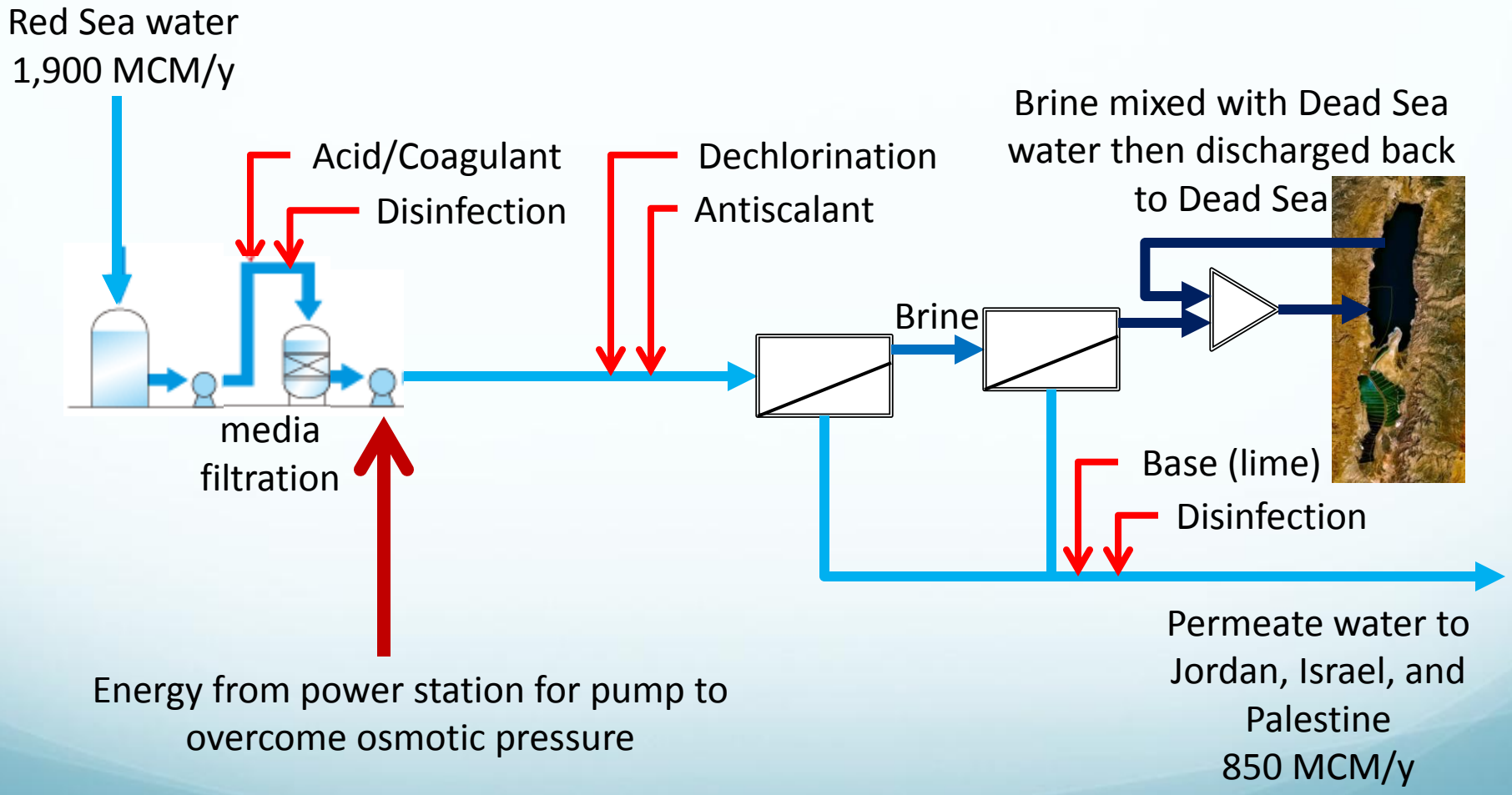
How to avoid scaling

- Minimize concentration polarization
  - Promote turbulence in feed channels
  - Increase speed of feed stream



- Add antiscalant to allow super saturation
  - PO_4^{3-}… causing disposal problem
  - Polyacrylic acid… preferred

RDSC Desalination Process



Post-treatment

- Add lime to eliminate acid added during pretreatment

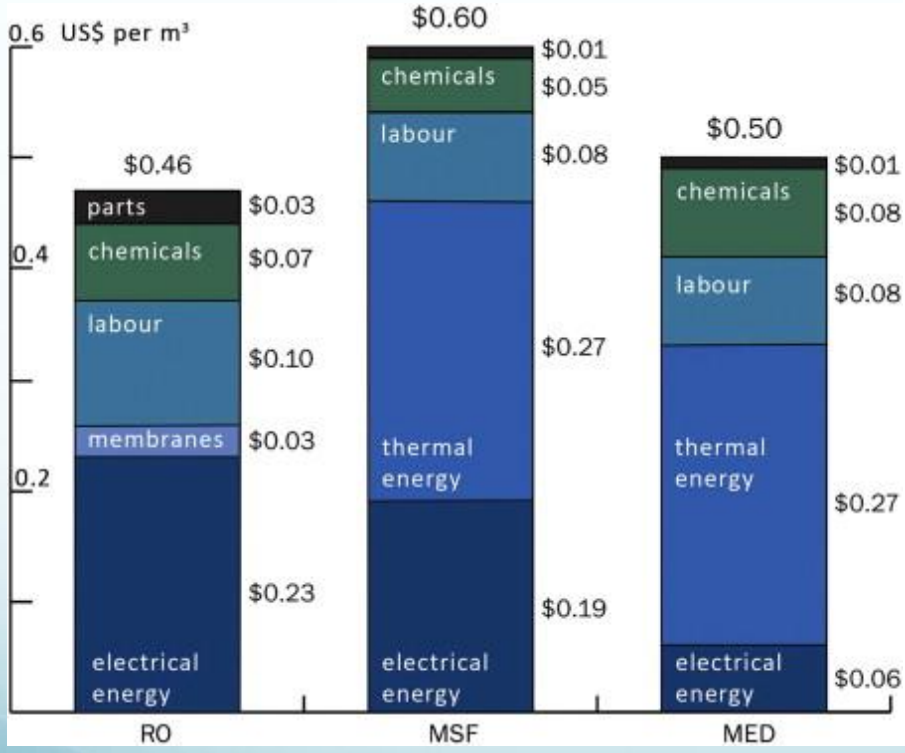
Post-treatment

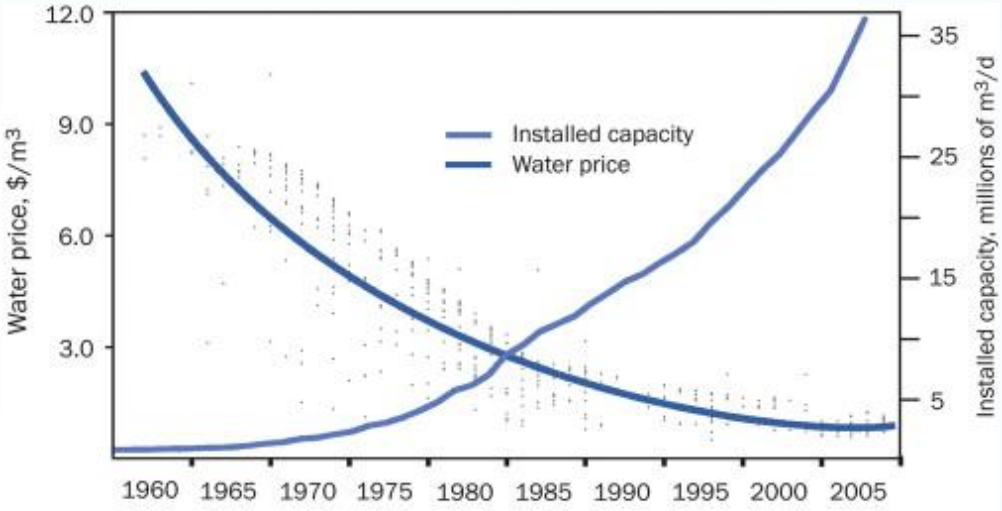
- Disinfection by adding chlorine

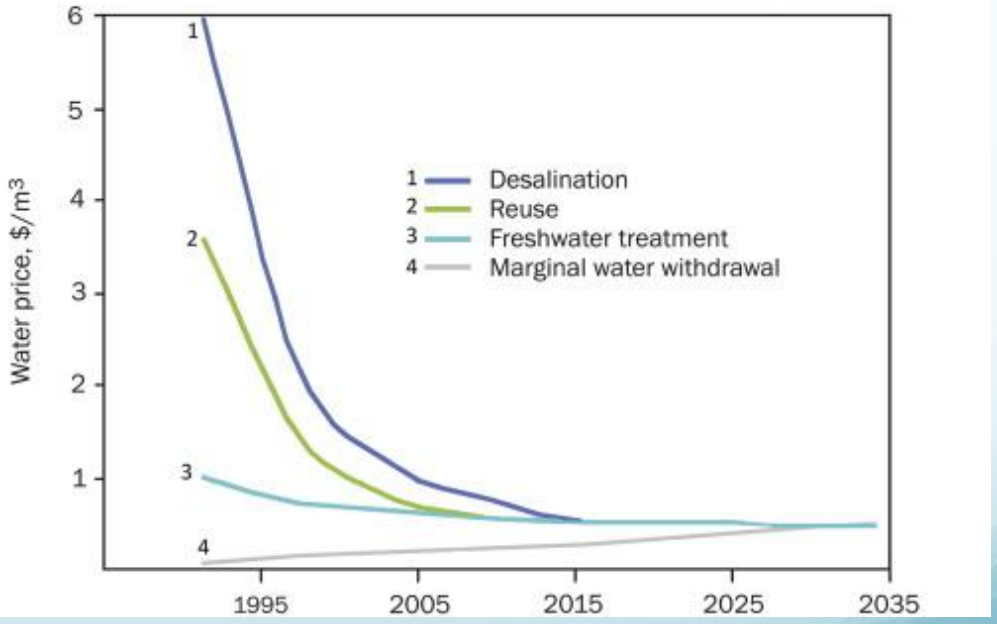
Environmental Impacts

- Gulf of Aqaba Marine Environment
- Brine Reject
- Dead Sea

Economy of RO Implementation







Lattermann et al. 2010

Conclusion

- Benefits
  - Restore Dead Sea
  - Provide freshwater to Jordan, Palestine, and Israel
  - Produce energy
  - Improve economy
- Concerns
  - Environmental degradation
  - Effects of brine on the Dead Sea
- Future Considerations

Acknowledgement

- Dr. Hani Abu Qdais
- Jaffer

شكرا جزيلا

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