Assessment of groundwater quality in State of Qatar for agriculture and domestic water supply applying membrane processes

Khaled Elsaid

Ph. D. Student, Chemical Engineering, University of Waterloo

Overview

- Introduction,
- Methodology,
- Results and Discussion,
- Conclusions and Recommendations,
- Acknowledgement

Introduction

- Fresh groundwater represent about 0.76 % of the total water available globally
- Saline/brackish groundwater represent about 0.93 % of the total water available globally
- The GCC countries are listed in the top 15 nations with groundwater having the largest share in the total annual freshwater worldwide (84 – 97 %)
- For State of Qatar, groundwater abstractions are dominated by abstraction for agriculture purposes with about 230 MCM in 2012.
- The two main groundwater basins are the Northern and Southern Groundwater Basins.

Introduction

- State of Qatar has one of the lowest precipitation rate worldwide, with average of about 82 mm with very high annual evaporation rate of about 2200 mm.
- State of Qatar has a continuous groundwater quality monitoring programme, administrated by WD at MoM&E since 1996,
- A total of 100 monitoring wells (from overall 344 wells) span all over the country,
- Detailed analysis of the main quality parameters, namely pH and electrical conductivity, along with analysis for the major cations: Ca++, Mg++, Na+, and K+; anions: HCO3-, Cl-, and SO4--, in addition to SiO2.
- This study carry out qualitative assessment of groundwater from 50 potential production wells for membrane desalination.

Methodology

- In most cases of groundwater desalination, the recovery is controlled by scaling with sparingly soluble salts usually dissolved in groundwater.
- The supersaturation of key salts such as $CaCO_3$, $CaSO_4$, and SiO_2 in brackish groundwater as feed to RO and concentrate streams has to be quantified in order to identify the key components that limit recovery.
- Antiscalent addition can mitigate the formation of such minor scales to much higher saturation index relative to the major scale salts.
- Broad spectrum antiscalent, can be used with supersaturation limits up to 3.5Ksp, 20Ksp, 105Ksp, and 1000Ksp for $CaSO_4$, $SrSO_4$, $BaSO_4$, and CaF_2 respectively

Methodology

- Upon concentration of some constituents naturally present in water, it starts to precipitate, as their ion activity product exceed the solubility product for such salts.
- In general, for salt ions or electrolytes present in water, it dissolves according to the following dissolution reaction:

$$A_m B_n(s) \Leftrightarrow mA^{n+}(aq) + nB^{m-}(aq)$$

$$K_{s0} = \left\{A^{n+}(aq)\right\}^m \left\{B^{m-}(aq)\right\}^n \qquad IAP = \left\{A^{n+}\right\}_{act} \left\{B^{m-}\right\}_{act} \qquad SI = IAP / K_{s0}$$

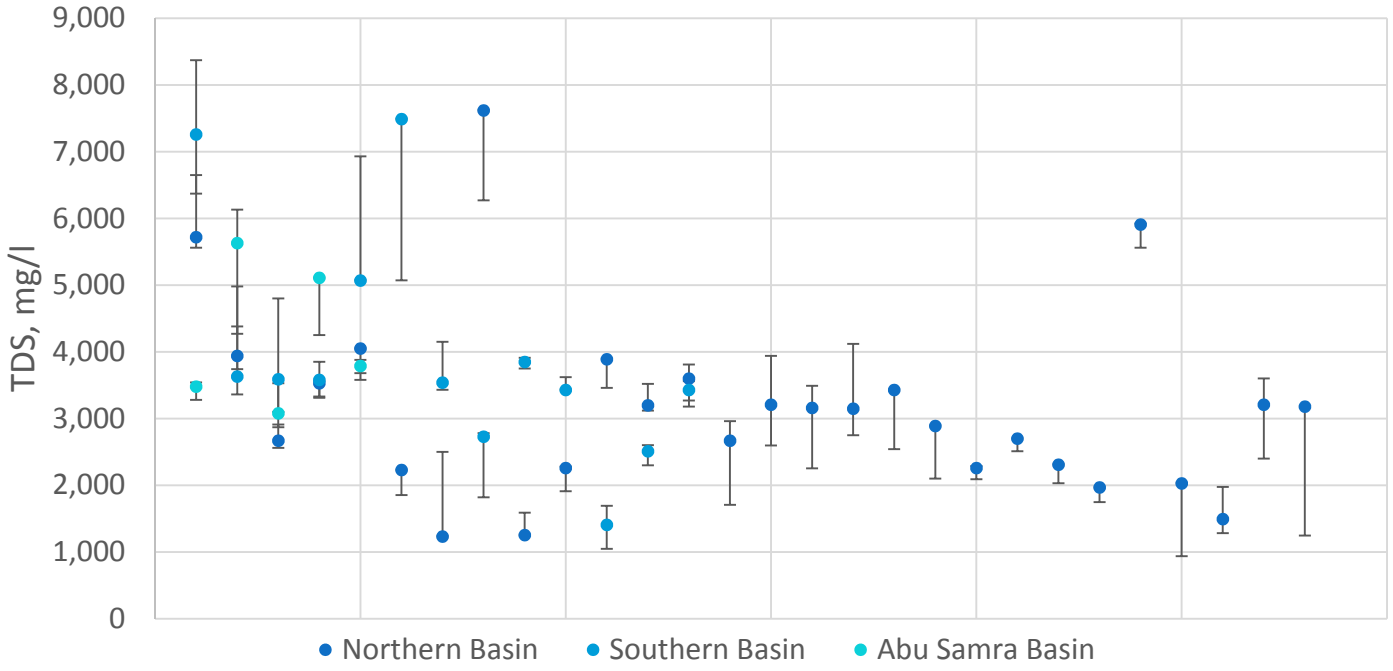
The result of such equation indicate one state of three, summarized as:

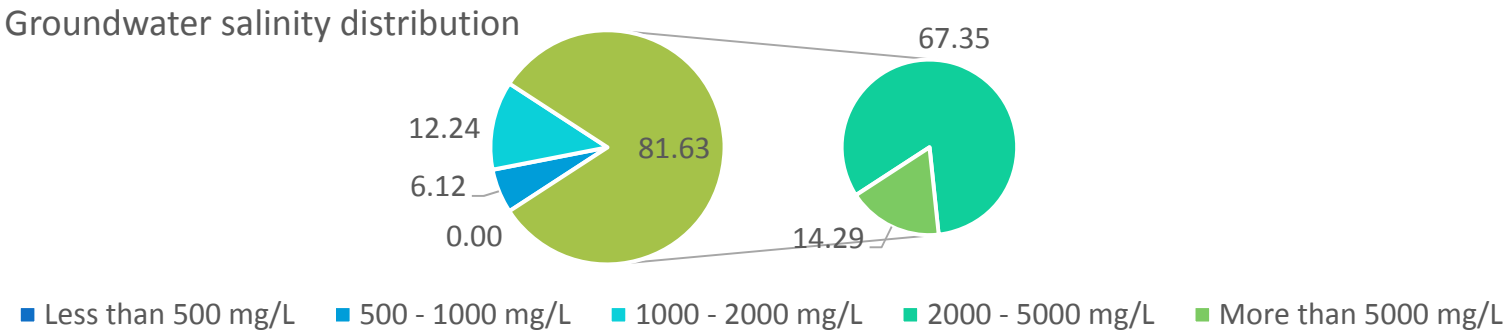
i. Oversaturated/precipitates: IAP $> K_{S0}$ and SI > 1,

ii. Saturated/equilibrium: IAP $= K_{S0}$ and SI = 1,

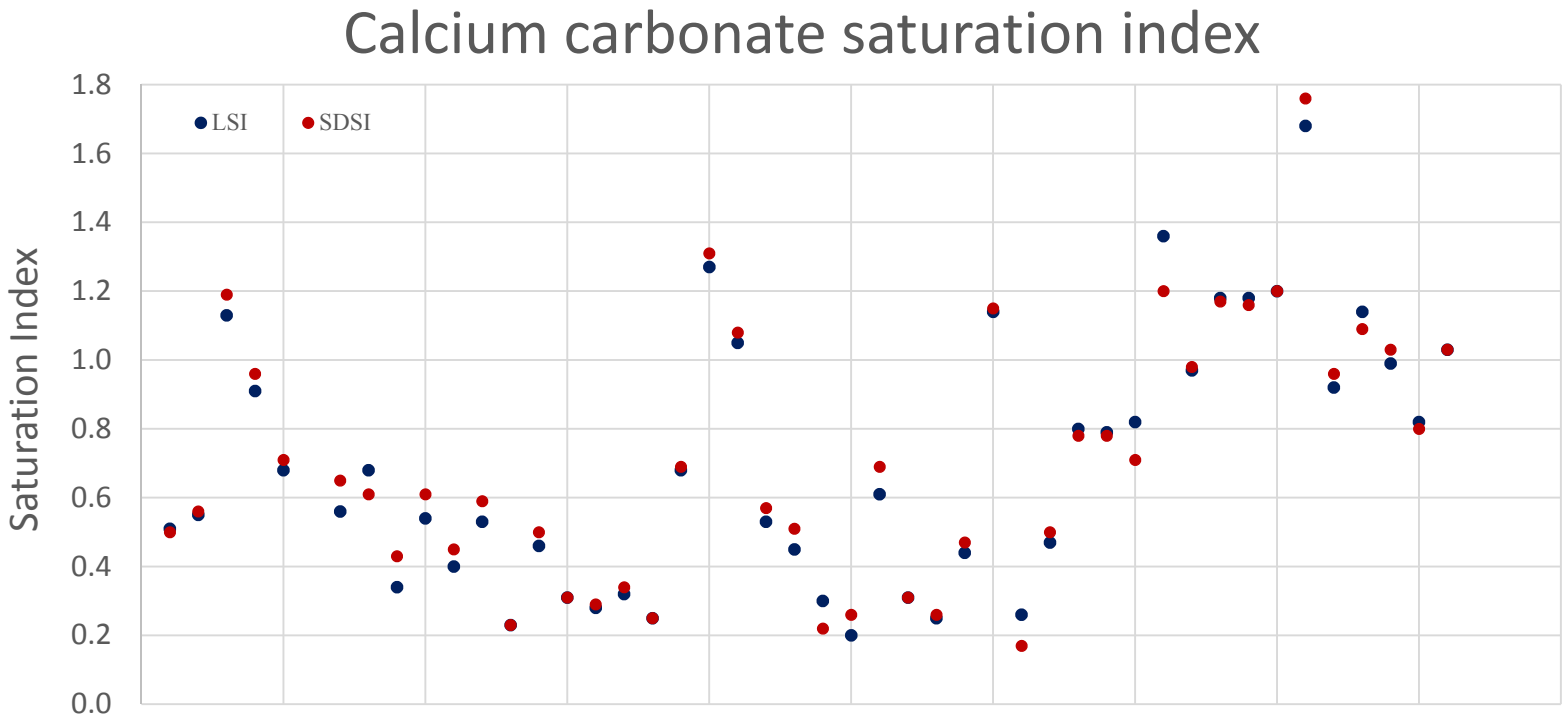
iii. Undersaturated/dissolves: IAP $< K_{S0}$ and SI < 1,

Results


9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
TDS, mg/l
Northern Basin
Southern Basin
Abu Samra Basin


Groundwater salinity distribution
67.35
12.24
81.63
6.12
0.00
14.29
Less than 500 mg/L
500 - 1000 mg/L
1000 - 2000 mg/L
2000 - 5000 mg/L
More than 5000 mg/L

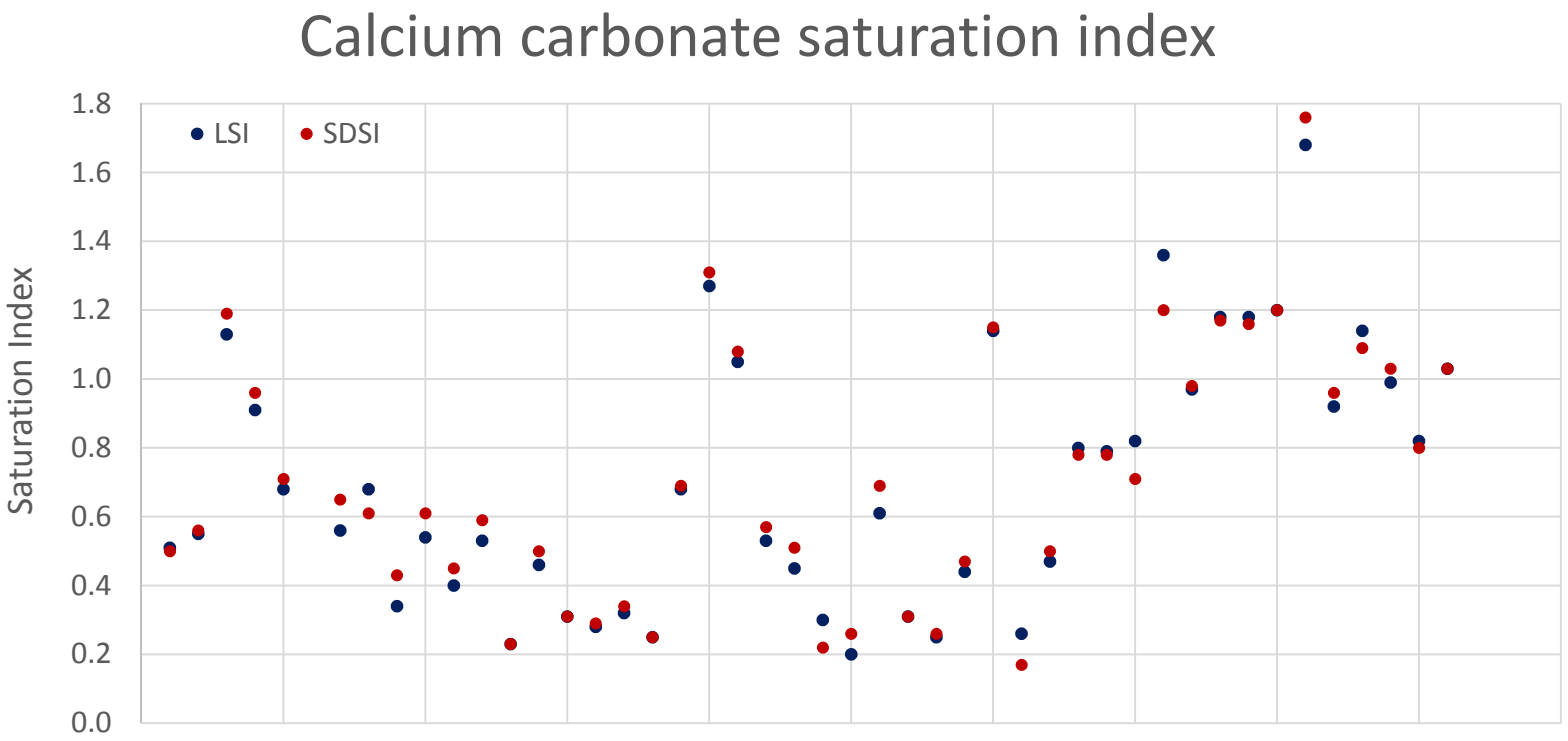
Results



$$LSI = pH - pH_s$$

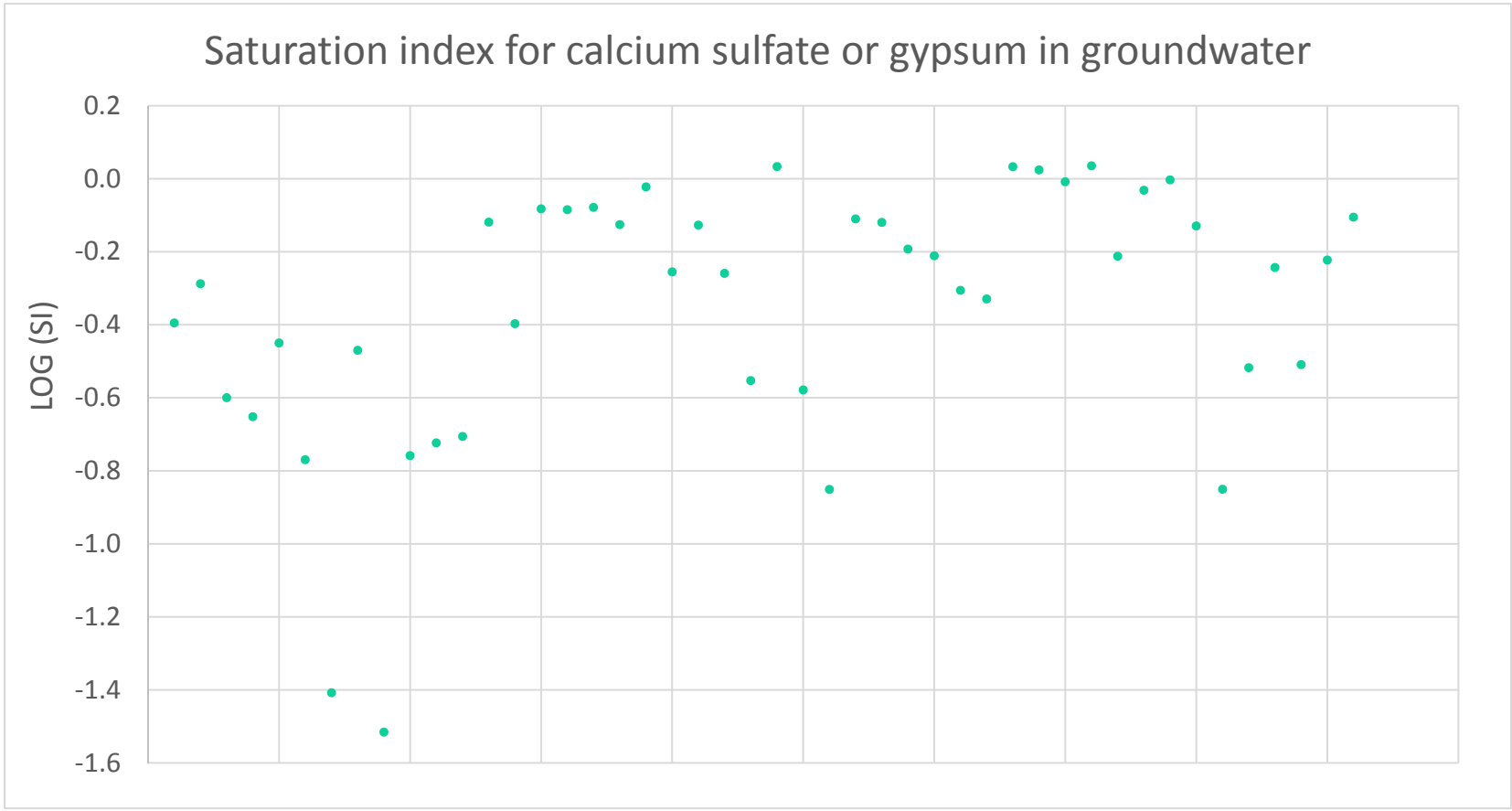
$$SDSI = pH - (9.3 + K - pCa - pAlk)$$

Results

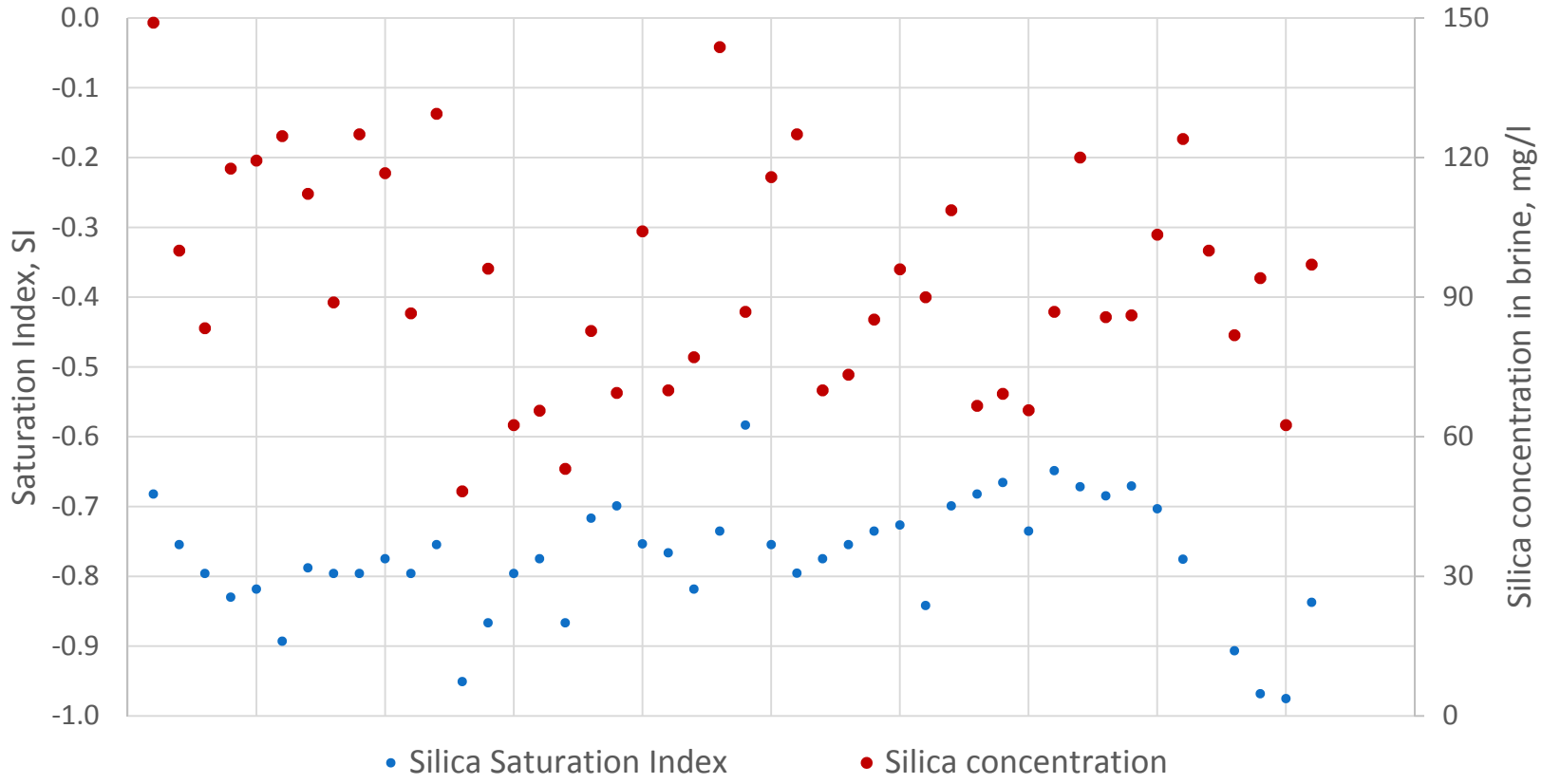


$$LSI = pH - pH_s \qquad SDSI = pH - (9.3 + K - pCa - pAlk)$$

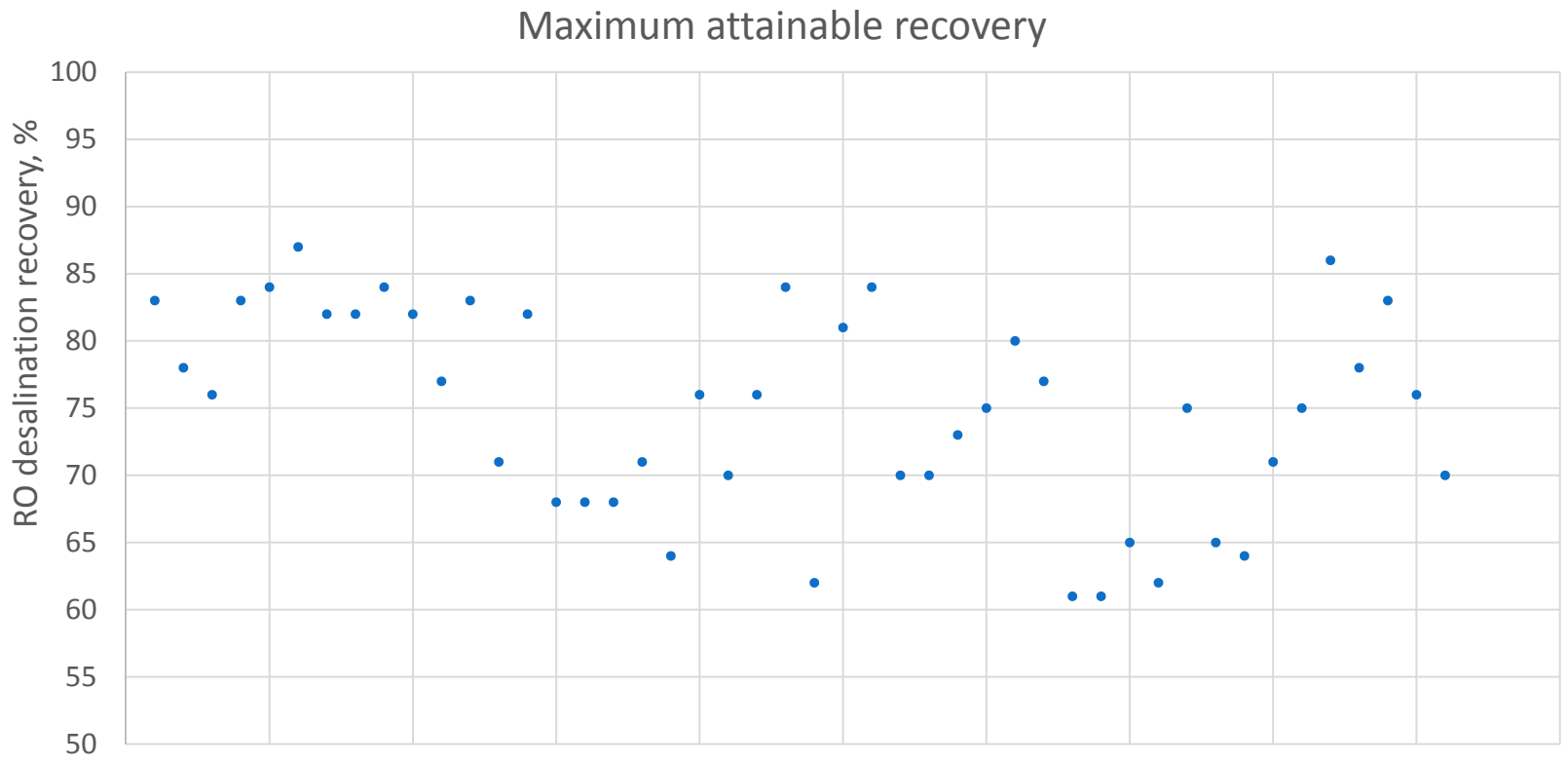
Results


Saturation index for calcium sulfate or gypsum in groundwater
LOG (SI)
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6

Results


0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
Saturation Index, SI
150
120
90
60
30
0
Silica concentration in brine, mg/l
Silica Saturation Index
Silica concentration

Results


Maximum attainable recovery
RO desalination recovery, %
100
95
90
85
80
75
70
65
60
55
50

Conclusion & Recommendations

- Application of desalination processes, is becoming more needed due to decreasing groundwater quality.
- Saturation due to gypsum was found to be the main recovery limitation, followed by silica limiting recoveries to 60 – 87 %.
- Brine management from GW desalination systems limits the wide application of such systems as most of these systems are located inland (i.e. disposal issue).
- As recoveries were mainly limited due to gypsum saturation, it is paramount to develop treatment processes which efficiently de-supersaturate the brine to enable higher overall recovery of groundwater desalination systems.

Acknowledgement

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Thanks for your kind attention

Q/A

Water Resource	Volume, (10^3 km^3)	Percent of total water	Percent of total fresh water
Saline water:			
Oceans/seas	1,338,000	96.54	-
Saline/brackish groundwater	12,870	0.93	-
Saltwater lakes	85	0.006	-
Freshwater:			
Glaciers and permanent snow covers	24,064	1.74	68.70
Fresh groundwater	10,530	0.76	30.06
Fresh lakes	91	0.007	0.26
Wetlands	11.5	0.001	0.03
Rivers	2.12	0.0001	0.006