Subsurface Water technologies for coastal aquifers: Case study in the upper aquifer of Boca del Río, México

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Subsurface Water technologies for coastal aquifers: Case study in the upper aquifer of Boca del Río, México

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1. Research Question

Could subsurface water technologies be a plausible solution to Boca del Río salinization problems?

2. About the Project

- Arcadis Netherlands (NL) contacted with Boca del Rio municipality (Mexico) and the Faculty of Engineering of the UNAM looking for assistance to develop: "Securing Water for Food: Grand Challenge" project, in Boca del Rio.

- Scientific partners: Arcadis NL; Water Cycle Research Institute, KWR, (NL); The International Water Association; AgroDer; UNAM (Hydrogeology Group, Fac. Eng.).

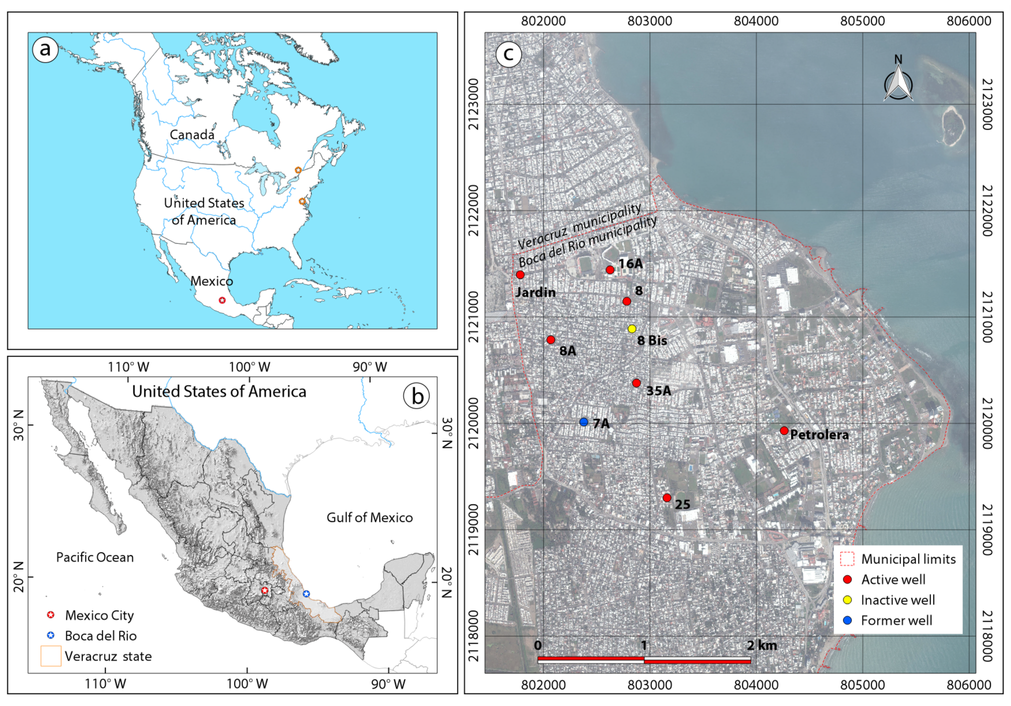

Figure 1. Location of the study area, (a) Mexico within the North American context, (b) location of Veracruz and Boca del Río Municipality, (c) Boca del Río urban area and overall location of groundwater wells for domestic supply.

3. Introduction

- The mixing with 3 - 4% of seawater is enough to render freshwater for most uses, producing serious environmental impacts added to large water demands in coastal zones (Custodio 2002).

- New technologies such as Fresh Keeper, ASR Coastal, Fresh Maker and HDDW developed by KWR, can effectively safeguard the water supplies from salinization problems. (J. K. Raat, et. al, 2009).

- We aimed to assess current salinization problems in Boca del Río – Costera de Veracruz aquifer system (Mexico, see Fig. 1) and stablish potential subsurface water solutions.

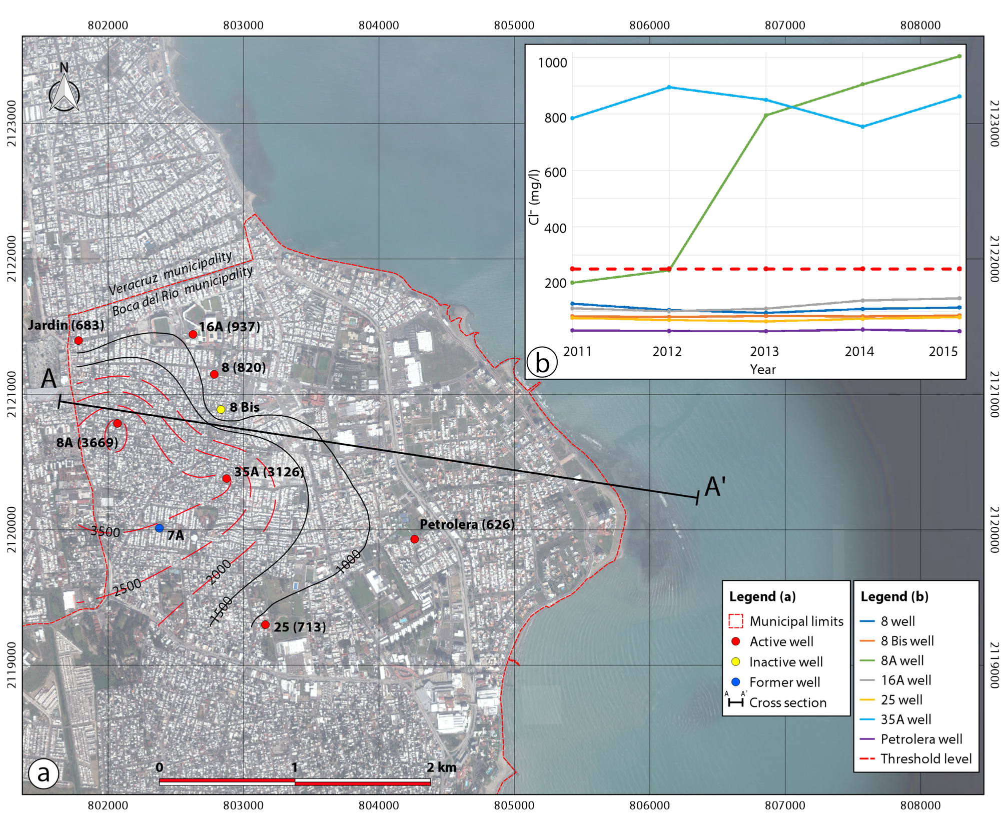

Figure 2. (a) Spatial distribution of electrical conductivity in the upper aquifer, (b) Temporal trend of chloride concentration vs. time (2011-2015) in Boca del Río production wells.

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4. Methods

- Nine drinking water wells (~20% of the human consumption in Boca del Río) were visited from May 26th-28th, 2015.

- Depth to water level and physicochemical parameters were measured with a Hanna HI 9828 Multiparameter.

- QGIS software 2.9 Wien (QGIS Development Team, 2009) was used to create, edit, visualize and manipulate geospatial information.

- The main features of the wells are shown in Table 1.

Well ID	Coordinates		Number of benefited persons	Total depth (m)	Screen length (m)	Casing diameter (in)	Flow rate (L/s)	DWT (m)	DDL (m)	
	UTM, X	UTM, Y							(a)	(b)
8	802783	2121147	32700	80	60	12	19	16	60	42.1
8A	802065	2120785		80	56	12	22	11.5	51.7	ND
8Bis	802632	2120888		80	74	12	33	10.3	27.3	ND
16A	802626	2121443		62	50.61	14	13	6.6	27.7	31.9
25	803161	2119299	6580	80	60	16	17	12.4	36.4	38.8
35A	802874	2120378	11400	73	51	14	23	7.7	31.5	37.4
Petrolera	804263	2119930	11400	29	17	14	14	3.5	8.72	ND
Jardín	801781	2121397	2300	100	72	12	15	8.5	28	32.9
7A	802378	2120011	ND	ND	ND	ND	ND	ND	ND	ND

5. Results and Discussion

- As shown in Fig 2.a, the distribution shows the opposite behavior concerning standard coastal patterns.

- Two high-salinity isolated spots (in wells 8A and 35A) are presented, surrounded by relative uniform Cl- concentrations exhibited in the remaining wells.

Well ID	DO (mg/L)	pH	Temp (°C)	Resistivity (ohm-m)	EC (µS/cm)	TDS (mg/L)	Redox (mV)
8	0.97	7.42	29.4	12.2	820	410	0.4
8A	3.9	7.28	28.22	2.73	3669	1835	1.92
8Bis	ND	ND	ND	ND	ND	ND	ND
16A	0.81	7.24	32.12	10.66	937	470	0.45
25	0.96	7.07	32.18	14.02	713	357	0.34
35A	3.46	7.5	29.2	3.2	3126	1562	1.62
Petrolera	1.98	7.02	31.23	16	626	313	0.3
Jardín	3.4	7.48	31.3	14.64	683	342	0.33
7A	ND	ND	ND	ND	ND	ND	ND

Table 2. Fieldwork results obtained with the Hannah Multiparameter on field level. In red, we showed the most salinized wells.

- ~70% of the total variation in salinity can be explained by the linear relationship between electrical conductivity and flow rates. Therefore, upconing effect (controlled by vertical upward movement of high salinity water underneath the bottom of the well) could be the major process that affects wells 35A and 8A.

- As noted in Fig. 2a, an abrupt salinization increase for well 8A was registered, in one year, from 2012 to 2013. This might be an indicative of the upconing effect, because lateral salinization controlled by the progress of seawater, is a much slower process.

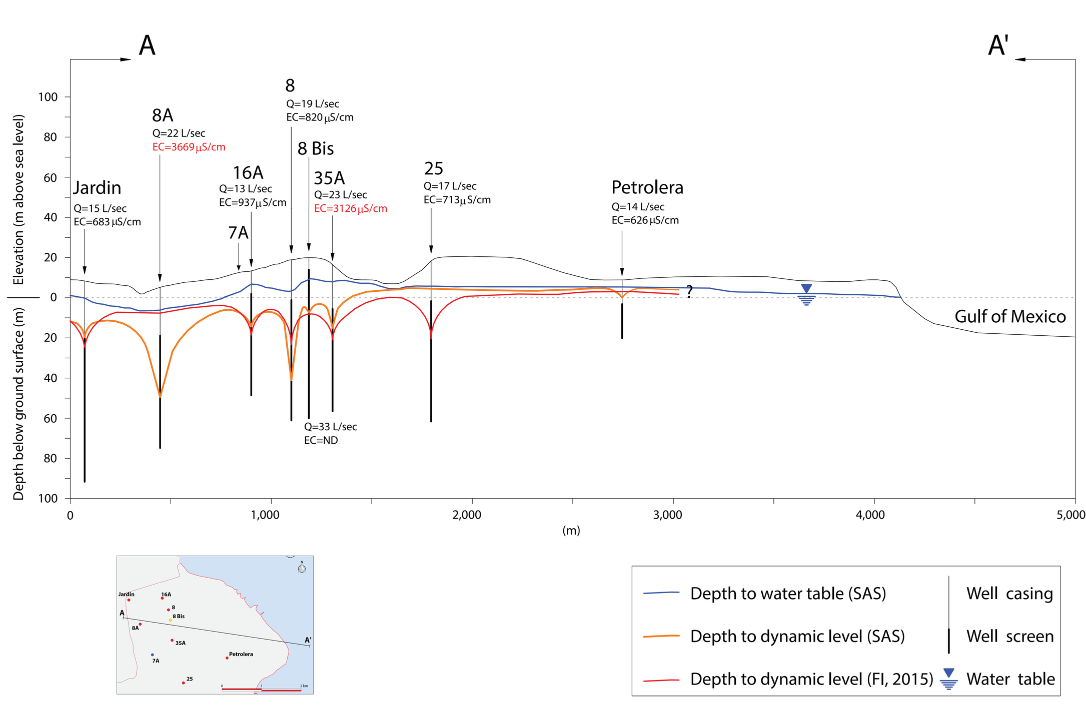
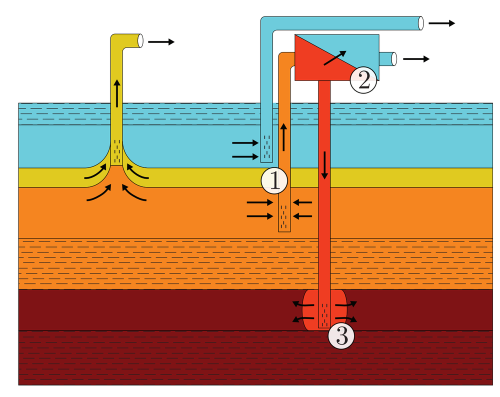


Figure 3. Hydrogeological cross section A-A', showing the groundwater wells Jardin, 8A, 16A, 8, 8Bis, 25 and Petrolera.

6. Possible solutions?

The freshkeeper could prevent the upconing effect and prevent salinization problems in the study area (P.J. Stuyfzand; J.K: Raat, 2009), see Fig. 4.



(1) intercept upconing brackish groundwater by simultaneously abstracting upper fresh and lower, intruding brackish water;
(2) use the abstracted brackish water as an additional water source, by desalting it through reverse osmosis;
(3) dispose the RO membrane concentrate by deep-well injection into a confined, more saline aquifer. (P.J. Stuy fzand; J.K: Raat, 2009).

Figure 4. Freshkeeper model by (P.J. Stuyfzand; J.K: Raat, 2009).

7. Conclusions

- Salinization in the upper (granular) aquifer is not attributed to regional processes from the encroachment of seawater front, but instead, due to punctual upconing processes in the affected wells (8A and 35A).

- We recommend TDEM soundings to discard other causes of salinization in these specific wells.

- Further research is needed in order to study the Freshkeeper technology as a feasible solution to Boca del Río salinization problems.

8. References

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P. J. Stuyfzand; J. K. Raat (2009) Benefits and hurdles of using brackish groundwater as a drinking water source in the Netherlands. Hydrogeology Journal 18, 117-130.

Acronym

DDL Depth to dynamic level
DO Dissolved oxygen
DWT Depth to water table
EC Electrical Conductivity
HDDW Horizontal directional drilled wells
ND No data
NL Netherlands
Q Flow rate
SAS Sistema de Agua y Saneamiento
TDEM Transient Domain Electromagnetics soundings
TDS Total dissolved solids
Temp Temperature

Acknowledgements

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