Saline water intrusion in Mexico

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ABSTRACT

It is presented a geohydrologycal description of the most important coastal aquifers in Mexico to evaluate the magnitude of the saltwater intrusion phenomena in the country.

INTRODUCTION

The knowledge of the relations between fresh water and salt water on coastal zones is very important because many aquifers spill their waters directly into the sea. The fresh water flow create an equilibrium state between both waters. This equilibrium can only be modified, after a long time, by natural causes due to climatic changes or due to relative movements of the earth and sea.

A lot of countries like Mexico, have a great length of coasts where different economic activities take place: tourism, fishing, agriculture, industry, etc. The development of these activities generate an important extraction of ground water and in consequence a modification in the relation between fresh water and salt water in the subsoil. Another causes that may modify the above ratio on these zones are the performance of engineering works that increase the natural drainage of the aquifers or incite the penetration of sea water through the rivers and channels, like occur in the excavation of ports in coastal zones; drying of zones inundated by the sea; dredged of rivers and channels to make them navigable, etc.

Because of the accelerated development of the coastal zones in Mexico in the last years, it is necesary to evaluate the saline water intrusion phenomena of the coastal aquifers in the country in order to open different choices for the rational exploitation of the ground water resources in these zones, avoiding in this way, the damage of the ground water quality and the abandonment of the wells. The objective of this paper is to present the results of the diagnostic made in the main costal aquifers in Mexico.

RECOGNITION OF SALINE WATER INTRUSION IN MEXICO

From the 17 states along the coast of Mexico, 10 have had some experiencing with sea water intrusion a brief description of each of these situations is presented follows. In table 1 it is presented an abstract of the situation and figure 1 shows the location of the saltwater intrusion aquifers in the country.

1. Baja California Norte

This state has 11 aquifers along the coast of the Pacific Ocean from which 4 of them are contaminated with saline water intrusion. The mainly contaminated aquifers are:

Camalú: the water table are between 4 and 16 m below sea level. From 57 wells observed, 29 were abandoned due the saltwater intrusion.

San Quintín: Since 1971, the aquifer presented saltwater intrusion due the high exploitation rate.

The aquifers along the coast of the Gulf of California do not have sign of saline water intrusion.

2. Baja California Sur

The satate has 12 aquifers along the coast of the Pacific Ocean and the coast of the Gulf of California. Saline intrusion appeared in the early 1980s in 6 of them, mainly in **San Juan de los Planes**, **San Jose del Cabo**, and **La Paz**. In **San Juan de los Planes** the exploitation of the aquifer has incited water table levels of 25 m below sea level in the major aquifer and the abandonment of many wells. In **San Jose del Cabo** the saline interface is 4.5 km inland. On the other hand, the battery of wells parallel to the coastal line (less than 5 km inland) has incited that the saline intrusion goes forward in **La Paz**.

3. **Campeche**

There are not sign about saltwater intrusion. The exploitation rate is under the natural recharge in almost all the aquifers.

4. Colima

The satate has 3 aquifers along the coast of the Pacific Ocean: **Tecomán-Armería**, **Valles Costeros** and **Cihuatlán**; since 1981, **Valles Costeros** aquifer has presented saline intrusion mainly in Jalipe-Tepeixples due the development of Manzanillo city.

5. Chiapas & 6. Guerrero

There are not sign about saline intrusion.

7. Jalisco

The most important aquifers in the state are: **Barra de Navidad** and **Bahía de Banderas** along them there are notices about water quality problems, however, due there are not water analysis it is not possible to know is the problem is due to saline intrusion.

8. Michoacán

La Coahuayana is the main aquifer in the zone, since 1980, the aquifer has been studied and no problem has been found. The exploitation rate is under the natural recharge.

9. Nayarit

There are 6 aquifers in the coastal zone. The most important are **Ixtlán del Río** and **San Pedro** where there are saline intrusion due the tides.

10. Oaxaca

The majority of the coastal aquifers are not studied, however, in **Itsmo de Tehuantepec** aquifer the authorities have been taking cautions to protect the aquifer against the saline water intrusion.

11. Quintana Roo

The state has 5 aquifers, 4 of them along the coastal line and one in **Isla Cozumel** where major intrusion has occured as a result of a increase in the pumping rate. The saline interface is 22 m inland.

12. Sinaloa

The most important coastal aquifers are: **Culiacán**, **Mocorito** and **Elota-Cañas** where the saline water intrusion started in the ending of the 1970s.

13. Sonora

The major saline water intrusion problems are present in this state where saline water intrusion is increasing due the overpumping of the wells mainly in **Caborca**, **Hermosillo** and **Guaymas**.

14. Tabasco & 15. Tamaulipas

There are not sign about saline water intrusion in any of the coastal aquifers.

16. Veracruz

The main aquifer is along the coast of Veracruz city where since 1981, there is saline intrusion due the overpumping of some wells in the zone.

17. Yucatán

The mainly coastal aquifers in the state are: **Progreso**, **Zona Hortícola** and **Dzonot Carretero** where due the high permeable rocks of the zone enable sea water to enter into the aquifer.

CONCLUSIONS

The saline water intrusion of coastal aquifers and ocean islands in Mexico has his origin mainly in the exploitation over the natural recharge of the aquifers.

Because of the gravity of the saline water intrusion in Mexico (almost the 43% of the total aquifers along coastal lines) the main objective of the studies in the future must be guided to arrange the phenomena.

It is necessary to install monitoring nets along the coastal zones to detect the saline front evolution.

REFERENCES

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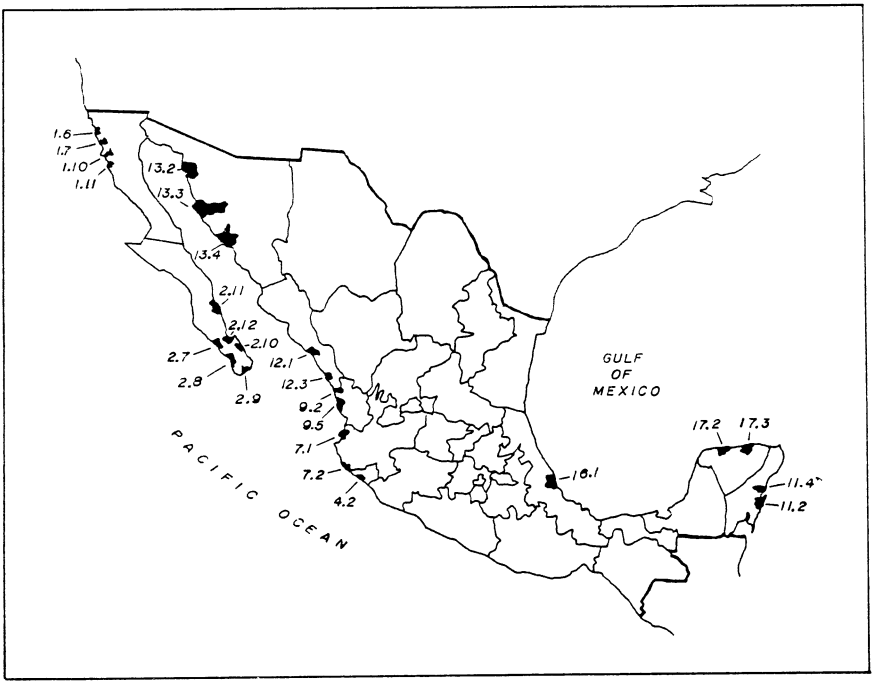

Figure 1. Location of the saltwater intrusion aquifers in Mexico

Table 1. Geohydrologycal conditions in coastal aquifers

No.	ZONE	ST.	AREA	STD (ppm)			CONDITION
			(Km2)	FROM:	TO:	MEAN:	
1.1	TIJUANA	BCN	620	573	3625	1600	OUT OF DATA
1.2	ROSARITO	BCN	350	1000	2000		OUT OF DATA
1.3	LOS MEDANOS	BCN	254		1000	1000	SUBEXP.
1.4	EL DESCANSO	BCN					SUBEXP.
1.5	LA MISION	BCN	613	593	4614	1800	OUT OF DATA
1.6	MANEADERO	BCN	1795	405	8157	1597	SALINE INT.
1.7	SAN VICENTE	BCN	1954	600	6800	1500	SALINE INT.
1.8	SAN RAFAEL	BCN	1300	900	5300	1900	SUBEXP.
1.9	SAN TELMO	BCN	1093	807	7776	3000	SALINE INT.
1.10	CAMALU	BCN	278	900	7000	2500	SALINE INT.
1.11	SAN QUINTIN	BCN	2673	1300	6000	2200	SALINE INT.
2.1	S. VIZCAINO	BCS	15100	332	1825		OVEREXP.
2.2	SAN IGNACIO	BCS	9150	576	1920		SUBEXP.
2.3	LA PURISIMA	BCS	2400	352	2048		SUBEXP.
2.4	EL MEZQUITAL	BCS	2200	600	1750		OVEREXP.
2.5	STO DOMINGO	BCS	1250	100	1000		SUBEXP.
2.6	SAN HILARIO	BCS	5390	700	1200		OUT OF DATA
2.7	LOS VIEJOS	BCS	1752	534	3500		SALINE INT.
2.8	V. SUROESTE	BCS	1824	2600	16344		OVEREXP.
2.9	SN J. CABO	BCS	1175	250	12800		SALINE INT.
2.10	SN J. PLANES	BCS	856	300	6000		OVEREXP.
2.11	LORETO	BCS	359	400	4000		SALINE INT.
2.12	LA PAZ	BCS		330	26000		SALINE INT.
3.1	ZONA COSTERA	CAMP					SUBEXP.
4.1	TECOMAN	COL					OUT OF DATA
4.2	V. COSTEROS	COL					SALINE INT.
4.3	CIHUATLAN	COL					OUT OF DATA
5.1	TONALA	CHIS	747	88	814	297	SUBEXP.
5.2	ZONA COSTERA	CHIS	2500	200	600		SUBEXP.
6.1	CUAJINICUILAPA	GRO	1800	129	953	356	SUBEXP.
7.1	B. DE BANDERAS	JAL					SALINE INT.
7.2	B. DE NAVIDAD	JAL					OUT OF DATA
8.1	COAHUAYANA	MICH					SUBEXP.
9.1	B. DE BANDERAS	NAY					OUT OF DATA
9.2	IXTLAN DEL RIO	NAY	5115	102	2866	611	SALINE INT.
9.3	ZONA COSTERA	NAY	600	134	1036	337	SUBEXP.
9.4	MATATIPAL	NAY	550	99	473	248	OUT OF DATA
9.5	Z. LAS VARAS	NAY	250	48	823	284	OUT OF DATA
9.6	SAN PEDRO	NAY	2500	147	4179	624	SALINE INT.
9.7	I. MA. MADRE	NAY	145	623	5073	1658	SALINE INT.
10.1	PINOTEPA NAC.	OAX					OUT OF DATA
10.2	I. TEHUANTEPEC	OAX					OUT OF DATA
11.1	LOS LIRIOS	QR	4835	311	8250	1211	SUBEXP.

Table 1. Geohydrologycal conditions in coastal aquifers

No.	ZONE	ST.	AREA	STD (ppm)			CONDITION
			(Km2)	FROM:	TO:	MEAN:	
11.2	LAZARO CARDENAS	QR	4000	333	1550		SALINE INT.
11.3	ARROYO UCUM	QR	3200	378	2800	1334	OUT OF DATA
11.4	F. CARRILLO PTO	QR		315	4483		SALINE INT.
11.5	ISLA COZUMEL	QR		500	1000		SALINE INT.
12.1	CULIACAN	SIN		300	3000		SALINE INT.
12.2	MOCORITO	SIN		200	2500		SALINE INT.
12.3	ELOTA-CAÑAS	SIN					SALINE INT.
13.1	SN L. RIO COL.	SON		1200	1700		OUT OF DATA
13.2	CABORCA	SON					SALINE INT.
13.3	HERMOSILLO	SON			20000		SALINE INT.
13.4	GUAYMAS	SON					SALINE INT.
14.1	CHONTALPA	TAB			1500		OUT OF DATA
15.1	V. COSTEROS	TAMP					SUBEXP.
16.1	VERACRUZ	VER					SALINE INT.
16.2	COATZACOALCOS	VER	250	100	250		OVEREXP.
17.1	PROGRESO	YUC					OUT OF DATA
17.2	ZONA HORTICOLA	YUC	4000				SALINE INT.
17.3	DZONOT	YUC	1800	148	6333	1152	SALINE INT.